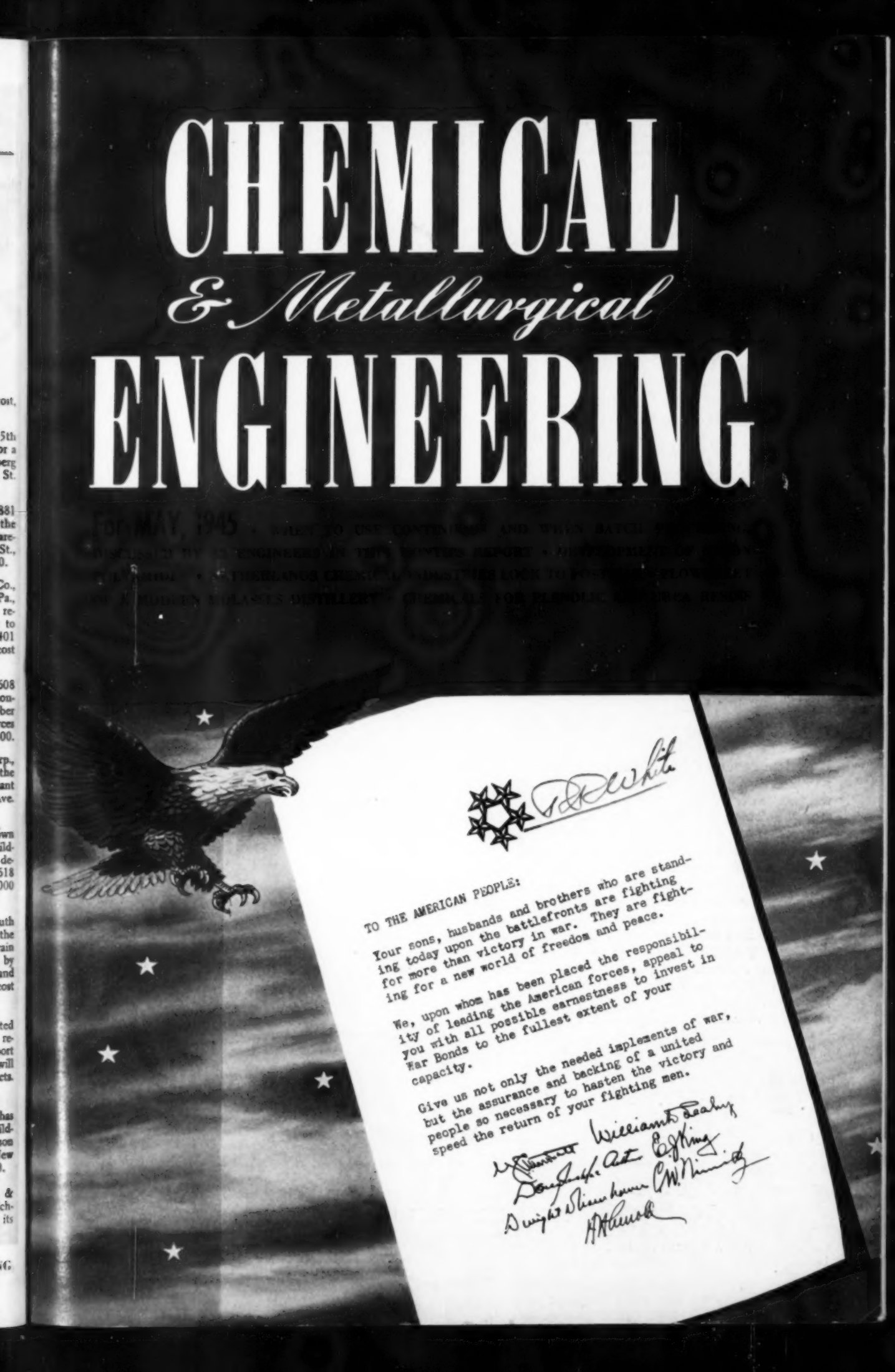
CHEMICAL & Metallurgical ENGINEERING

FOR MAY, 1945


TO THE AMERICAN PEOPLE:
Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.
We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.
Give us not only the needed implements of war, but the assurance and backing of a united people so necessary to hasten the victory and speed the return of your fighting men.

Cooked and Cooled in 3 Minutes

Here is a remarkable dish: Aluminum stearate grease, heated during the course of processing from room temperature to approximately 300 degrees—nearly flash point—in 1½ minutes, cooled again in the same fraction of time! And so the ticklish problem of achieving fast and efficient heat transfer with this volatile material is no longer a problem, when handled under cover in the continuous, closed Votator grease processing system.

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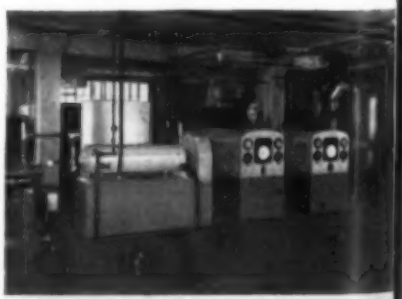
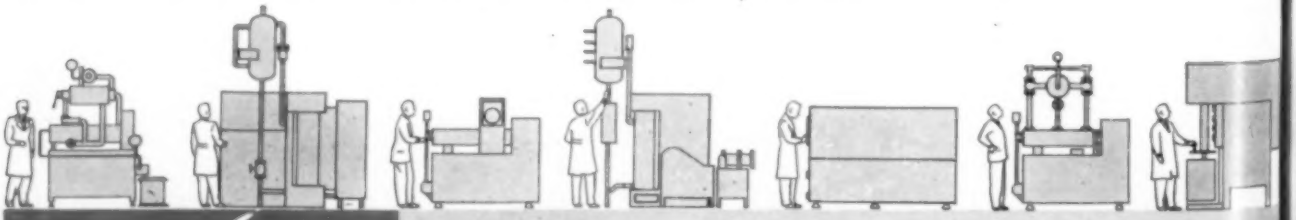


Compact, too! This typical Votator installation processes 1500 to 2000 pounds of aluminum stearate grease per hour in less than 300 square feet of floor space.



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CHEMICAL ENGINEERING

MAY • 1945

Volume 52 Number 5

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NATURE found it comparatively simple to insulate a streamlined job like the seal, but did you ever try to wrap up a giraffe? Men who have to insulate flanged or threaded fittings in a piping system will readily understand the comparison. By the same token, Tube-Turn welding fittings give a streamlined silhouette which is easily insulated, with never a leak to cause insulation replacement.

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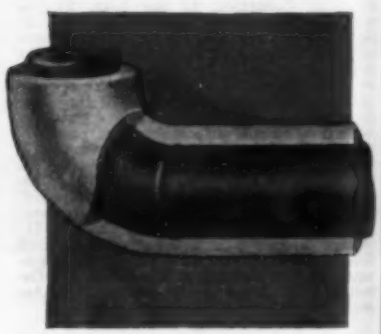

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Because Tube-Turn welding fittings make smooth, leak-proof turns, insulation goes on easily, never needs to be removed because of leaks.

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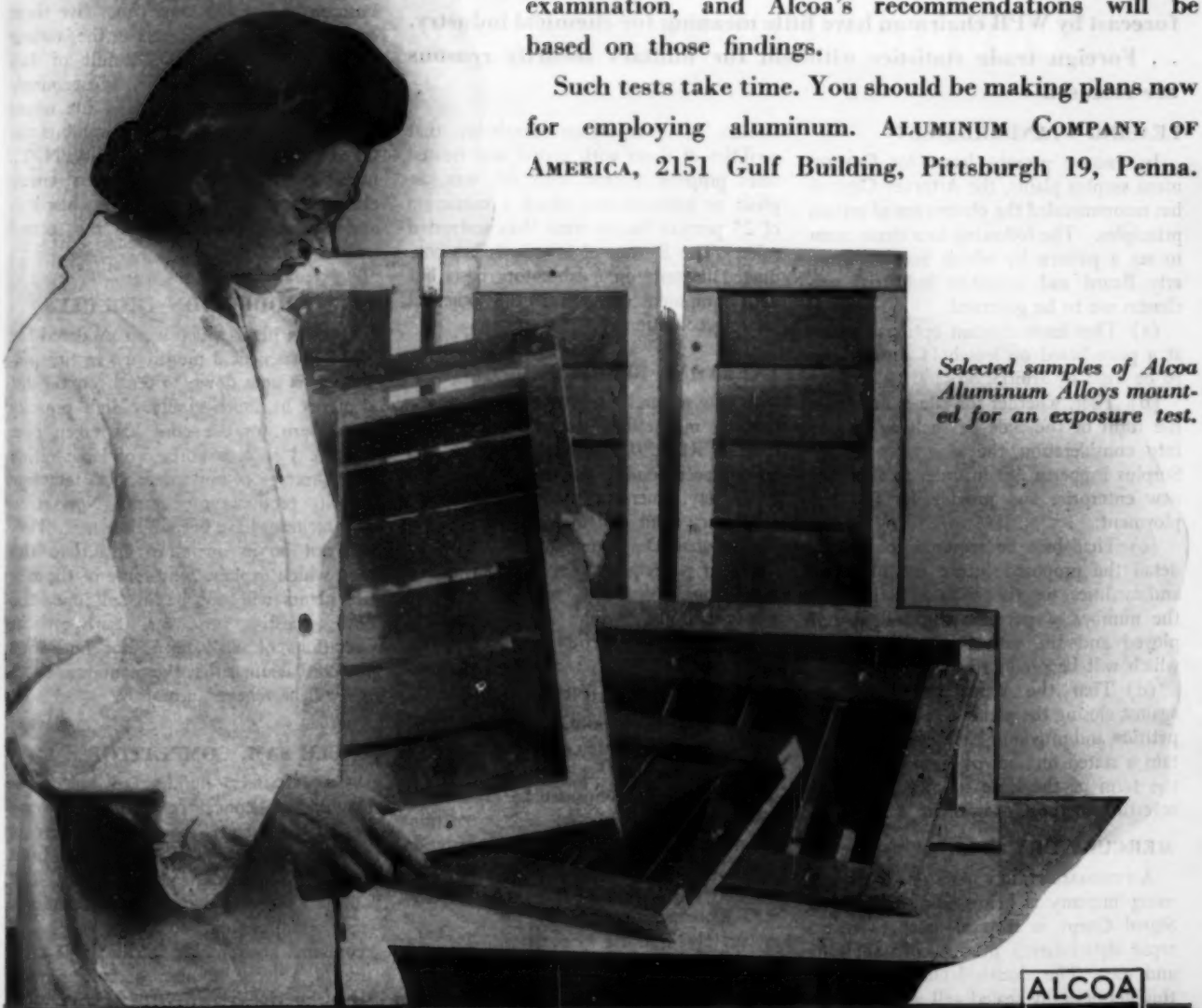
What aluminum alloy will perform best on a specific task?

Tests at Alcoa's Research Laboratories can evaluate the corrosion resistance of aluminum alloys under approximate operating conditions. But, put into service, some seemingly unimportant factor may alter the entire picture—minor impurities in materials being processed, flow rates or temperatures. Test exposure *on the job* is indicated, therefore.

The specimens pictured here were prepared by Alcoa for this purpose; other sizes and shapes also are available. They're now being exposed in existing equipment. They'll be returned after a suitable period for minute examination, and Alcoa's recommendations will be based on those findings.

Such tests take time. You should be making plans now for employing aluminum. ALUMINUM COMPANY OF AMERICA, 2151 Gulf Building, Pittsburgh 19, Penna.



Selected samples of Alcoa Aluminum Alloys mounted for an exposure test.

ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM

WATCHING WASHINGTON

R. S. McBRIDE, Editorial Consultant • PAUL WOOTON, Chief of McGraw-Hill Washington Bureau • MALCOLM BURTON, Washington Correspondent

New type of dry cell is used by Signal Corp. . . Mail carriers find plastic shoe soles wear much longer. . . Radical fertilizer bills proposed. . . Census makes plans for much more complex survey than heretofore. . . Promise to Chile that U. S. would not operate government synthetic ammonia plants after war stirred a lot of comment. . . Ample supply of grain available for industrial alcohol. . . Industry urged to place orders for maintenance, repairs and operating supplies at once. . . Allocations of certain chemicals after V-E Day as forecast by WPB chairman have little meaning for chemical industry. . . Foreign trade statistics withheld for military security reasons are released

LEASING STANDARDS SET

IN URGING prompt leases for Government surplus plants, the Attorney General has recommended the observance of certain principles. The following four items seem to set a pattern by which Surplus Property Board and would-be industrial purchasers are to be governed:

(a) That leases contain options for sale at a price based on leasehold earnings, or to be fixed by arbitration:

(b) That, whether for sale or for lease, the form of the bids be such as to take into consideration the objectives of the Surplus Property Act in order to stimulate new enterprise and provide for full employment;

(c) That bids be required to state in detail the proposed future use of plants and facilities, together with an estimate of the number of persons who will be employed and the articles or commodities which will be produced;

(d) That the leases contain clauses against closing the plants to eliminate competition and providing that the lessee maintain a stated number of employees during the term of the lease to prevent it from reverting to the Government.

MERCURY DRY CELL

A FUNDAMENTALLY new type of dry cell using mercury is being employed by the Signal Corps in tropical areas to reduce rapid deterioration during both shelf life and use. The electrical characteristics of this hermetically sealed cell are also superior for some applications.

PLASTIC SOLES TESTED

WPB and the Bureau of Standards have been making extensive tests of the wearing qualities of shoes with plastic and treated soles. WPB by practical use by 120 mail carriers in Washington concludes that qualities of shoes with plastic and treated soles properly treated with oil, wax, asphalt or nitrocellulose afford a minimum of 25 percent longer wear than untreated soles. The Bureau of Standards has conducted its tests on a laboratory basis but with equipment closely imitating practical wearing conditions.

EVERYONE BENEFITS

A NEW research program to develop new uses for magnesium has been inaugurated by the RFC. Universities, colleges and schools accredited by the American Chemical Society, American Institute of Chemical Engineers, and Engineers' Council for Professional Development have been invited to participate. Each school undertaking an investigation will be furnished up to 200 lb. of pure magnesium ingot for student experimentation.

PATENT MISUSE PROBED

PRESIDENT TRUMAN has directed the Department of Commerce to make a thorough investigation to determine whether patents are being "misused to support unlawful monopolies." In his instructions he directs a study be made in cooperation with the Department of Justice and other interested agencies so that the President and Congress may be able to determine accurately whether the patent laws are contributing to unwarranted monopoly.

WPB CRACKS DOWN

OPERATIONS of WPB's Compliance Division are becoming more vigorous. There has been an increase in decisions against industrial firms for infractions of official regulations, particularly for not keeping adequate inventory records as provided by Priorities Regulation No. 1. The increase in violations indicate a feeling that with the end of the war in Europe there will be a corresponding relaxation in requirements, say the spokesmen for the Compliance Division. Actually, they say, there is no promise that there will be any relaxation in the regulations until after the defeat of Japan, if then.

Stated policy of the Compliance Division is one of trying to keep firms in business and at the same time have them operate within the terms of the various government regulations. Result of this policy has been a number of seemingly mild orders. One of these is the recent Consent Order C-290 which prohibits the Gloss-Flo Corp., Long Island City, N. Y., manufacturer of lacquers, thinners, enamels, etc., from accepting certain chemicals and aromatic solvents during the second quarter of this year.

TIRE PRODUCTION TROUBLES

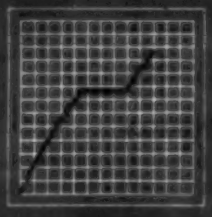
CARBON black which was considered the No. 1 bottleneck a month ago in tire production is now down to tenth on the list of items in short supply. High tenacity rayon yarn for tire cord has taken over the No. 1 spot. Shortage of labor rather than shortage of raw materials is retarding capacity production of yarn. New rayon cord facilities have been authorized. They will not be in operation until late this year, which explains why some of the new tire plants will not be in full operation until some time next year. Early capacity operations of all facilities for both tires and cord assumes that the manpower shortage will be relieved promptly.

UNCLE SAM, COMPETITOR

GOVERNMENT building of plants to manufacture concentrated phosphate and potash fertilizers is specifically ordered by a bill introduced in the Senate by Lister Hill and John Bankhead of Alabama. That bill also proposes many other fundamental new fertilizer and chemical policies. It represents an assembly into a single measure of a large number of reform plans which previously have been separately proposed.

Enactment of so general a measure seems unlikely. But the bill appears to be at least one of the areas in which industry must fight out to a finish the question as to how far the government will go into business. It represents the spearhead of

PROVEN RELIABILITY
Their durability and economy has been proven with millions of hours of service all over the world.



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Complete SpeedRanger is designed and built by one responsible worker in one plant.

INFINITELY VARIABLE SPEED
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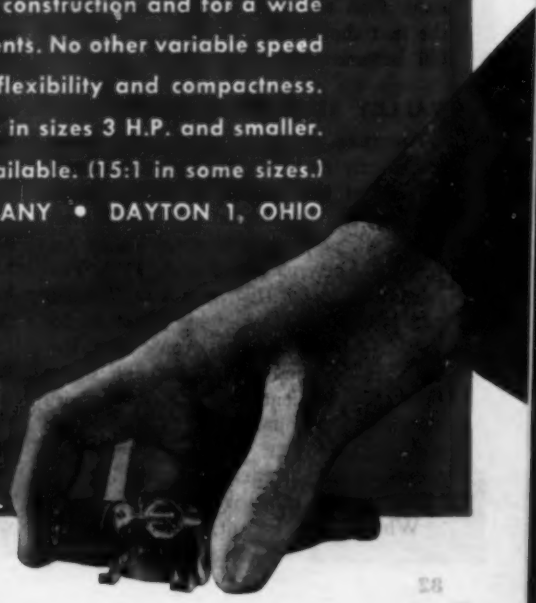


COMPACT
Integral, compact design saves space, saves time, saves money. Improved appearance.

the attack on many divisions of chemical process industries back of which proponents hope to gather pro-labor, public ownership, free fertilizer, anti-utility, and other powerful lobby groups. Were all these groups to be welded into an effective bloc, enactment of legislation of extreme form would be possible. But such coherence in a group of differing or even conflicting purpose seems unlikely. Nevertheless, this bill and others on related subjects will require close watching for the rest of this Congress.

OTHER PROPOSALS

THIS radical fertilizer-policy bill proposes other novel plans among which are: (1) Withholding of all reserves on public lands of phosphate and potash minerals for exclusive exploration and development by the government. (2) Official government sponsorship of huge farm cooperatives which would become the distributing agencies for fertilizers, and presumably later for other such things as insecticides and agricultural supplies from various industries. (3) The fixing of a national fertilizer policy under the Department of Agriculture. (4) The establishment of a national farm demonstration program to stimulate fertilizer use.

And in addition the bill would speed up the activities of TVA, especially its further manufacture of fertilizers and distribution and demonstration work.

The bill was drafted by American Farm Bureau Federation, apparently in an effort to bring together a large number of diverse and somewhat conflicting interests. It seems to have alienated some groups. Certainly the various farm organizations are in conflict as to certain features of the legislation. It is expected that this extreme form of bill will somewhat clarify the alignment of many groups for or against the whole public ownership program. It certainly will bring together fertilizer, insecticide, chemical, and many other industrial groups who see much more than the nose of the camel inside the tent should even a major part of this bill become law.

VALLEY AUTHORITY FIGHT

ANOTHER round of a long and bitter controversy as to further industrial development of this country is being fought currently in Washington over the Murray bill which proposes a Missouri Valley Authority, largely patterned after TVA. Proponents thought that President Truman had given the MVA a big boost in his comment at his first press conference. But close examination of the record shows that the President favors comprehensive waterway development on the Missouri and its tributaries; but he has opposed quietly and very effectively anything like another TVA for that area.

While vice president, Mr. Truman arranged that three separate committees of the Senate should have two months each for successive review of this bill. Thus he secured a six-month delay in the time when the Senate can vote on the proposal. No advocate of a bill would have taken such a stand. Only a very clever opponent could have maneuvered so long a delay.

The President probably strongly favors comprehensive waterway development to give upstream irrigation and downstream flood control with a coordination that insures both effectiveness and minimum cost. He is not clearly on record as opposed to the entry of the government into power, fertilizer, or other business, perhaps even including barge line operation. But those acquainted with his record and activities believe that he is unalterably opposed to all these government activities.

Certainly there remains no one now able to rally back of this Valley Authority idea anything like the large number of diverse groups which President Roosevelt did bring together to back his favorite concept of government handling many affairs in such organizations.

TVA SET BACK

WHILE MVA advocates are having their troubles in getting any favorable congressional consideration, the parent valley authority, "Yardstick" TVA, is also in trouble. It has lost a number of important staff members. Its chairman David Lilienthal is vigorously opposed for reappointment by congressional critics. And the appropriations committee of Congress has refused to reappropriate $3,000,000 for the phosphorus plant at Mobile. TVA got that money about three years ago but has not been able to spend it because it could not get priorities for needed equipment and scarce construction materials.

CENSUS PLANS MADE

A COMPLETE census will be taken of all manufacturing industry beginning next January. The investigation will cover the manufacturing operations of the calendar year 1945.

A comprehensive reclassification of industry has been made by Central Statistical Board which now governs the classification of manufacture both for Social Security Board and Census purposes. Gradually all other agencies of the government are reorganizing their statistical work to conform to this classification. Thus the data from various bureaus will become comparable for the first time, it is hoped.

The Census inquiries for chemical enterprise will give more attention to commodity data than formerly. It is hoped that a very complete report can be had on the production of every individual chemical and other product of chemical engineering enterprise. Much more data will be gathered regarding the raw materials consumed in making these products. Exact plans are not yet completed because the amount of money and staff available is not yet definitely known; but it appears that a much more comprehensive study will be made than has been possible for quite a number of years.

The last previous Census of Manufactures was taken in 1940, covering the operations of 1939. It is expected that the job done next year will be much more complex unless Congress demands unexpected economies. If so, the inquiry forms and schedules now being prepared will have to be cut back to much simpler forms than are now in the works.

BASING POINT BAN

PRICING of commodities with the use of a single basing point for freight charges, in which some fictional rather than actual place of shipment is assumed, constitutes unlawful discrimination among customers. This in effect is the finding of the U. S. Supreme Court on April 23 in the case where Corn Products Refining Co. was under attack by Federal Trade Commission. In this and a similar case involving A. E. Staley Manufacturing Co., the court ruled in a manner that seems to eliminate much of the basing point price practice of several industries.

The charge here was that by using an assumed point of shipment, rather than the actual one, the companies had unfairly and unlawfully established different prices for corn sirup. The discrimination violated the Clayton Act and the Robinson-Patman law which provide for equal treatment of customers of like sort who are themselves competitors. Numerous industries may have to revise their basing point price systems as the government proceeds to apply this final court decision.

SYNTHETIC VS. NATURAL

THE PROMISE to Chile that Uncle Sam would not operate government-owned synthetic ammonia plants except for war purposes stirred a lot of comment. The State Department was basing this promise to leave American markets open for natural Chilean nitrate on a more general pledge made in 1942. That earlier promise was resolution No. IX adopted by the conference of Ministers of Foreign Affairs of the American Republics meeting at Rio de Janeiro during January 1942. That resolution cited "emergency industries which under normal circumstances would be considered as uneconomic" and closed with the following:

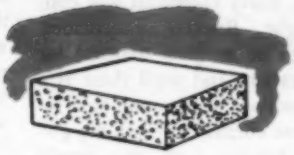
"Resolved: That the nations of the Americas stimulate the development of the basic production of each of them, avoiding insofar as possible the establishment or expansion of production of substitute or synthetic commodities which is economically artificial and might displace the consumption of natural products available

how TO BUILD AN ACID-PROOF FLOOR THAT WILL STAND UP EVEN UNDER ABNORMAL CONDITIONS

THE PROBLEMS involved in corrosion-resistant floor construction are so many and so varied that it is small wonder that such floors are a source of so much trouble to engineers and maintenance men alike.

The procedure outlined below, based on our experience of 80 years in handling corrosive problems, will give a floor of proven durability and economy — a floor that will stand up not only under traffic loads, but under exposure to oil, water, acids, alkalies, and solvents and is reasonably resistant to thermal and impact shock.

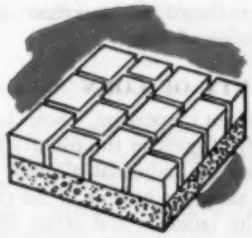
1st Start with a rigid, solid base. The ideal base is rigid concrete, 3" to 4" thick, even thicker, if traffic conditions are severe.



2nd Cover the concrete base with several layers of tar paper. All posts, curbs, drains, etc., should be carefully flashed in—just as carefully, in fact, as if you were preparing a roof.

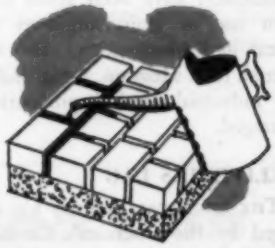
3rd Mop the entire area with either U. S. Stoneware's Resilon or U. S. Stoneware's Calktite. Both are applied hot (about 200°F). Don't be stingy, use plenty of Resilon or Calktite. Cover the entire area to a depth of approximately ⅛". Remember, this membrane is designed to prevent sub-surface seepage. Prepare it carefully.

4th Lay the floor with "U. S." Acid-proof Ceramic or Carbon Brick*, allowing ¼" joint space between the brick, and place the roughened non-skid surface out. Thickness of the brick depends on traffic conditions—for light traffic the minimum should be 1⅛", for heavy duty traffic 2¼". It is rare that more than one course is required.



**Carbon brick if hydrofluoric acid is present. Some sacrifice in wearing qualities must be anticipated.*

5th Bond the acid-proof brick with a good sulphur-base cement such as Portite, Super-Portite, or Carbo-Portite, by pouring the cement (hot) into the joints. If a sulphur-base cement will not resist the particular corrosive conditions in your plant, fill the joints only to within ⅜" or ½" of the top, then point the joints with Durisite, an acid, alkali and solvent-resistant resinous cement.



It is important to remember that even with time-proven design, the ultimate life of the floor depends on: (1) careful workmanship, and (2) the best materials. The U. S. Stoneware products recommended for use: "U. S." Acid-proof ceramic or carbon brick, Resilon, Calktite, the Portite series of sulphur-base cements, and Durisite acid-and-alkali-resistant resinous cements, are recognized as tops in their respective fields by chemical engineers everywhere. They are backed by a reputation built through 80 years of service to the chemical and allied industries. All materials mentioned are available for immediate shipment.

If you will send us your flow sheet, together with information regarding corrosive and service conditions, we will be glad to recommend the specific materials best suited and enumerate the items required.

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the attack on many divisions of chemical process industries back of which proponents hope to gather pro-labor, public ownership, free fertilizer, anti-utility, and other powerful lobby groups. Were all these groups to be welded into an effective bloc, enactment of legislation of extreme form would be possible. But such coherence in a group of differing or even conflicting purpose seems unlikely. Nevertheless, this bill and others on related subjects will require close watching for the rest of this Congress.

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VALLEY AUTHORITY FIGHT

ANOTHER round of a long and bitter controversy as to further industrial development of this country is being fought currently in Washington over the Murray bill which proposes a Missouri Valley Authority, largely patterned after TVA. Proponents thought that President Truman had given the MVA a big boost in his comment at his first press conference. But close examination of the record shows that the President favors comprehensive waterway development on the Missouri and its tributaries; but he has opposed quietly and very effectively anything like another TVA for that area.

While vice president, Mr. Truman arranged that three separate committees of the Senate should have two months each for successive review of this bill. Thus he secured a six-month delay in the time when the Senate can vote on the proposal. No advocate of a bill would have taken such a stand. Only a very clever opponent could have maneuvered so long a delay.

The President probably strongly favors comprehensive waterway development to give upstream irrigation and downstream flood control with a coordination that insures both effectiveness and minimum cost. He is not clearly on record as opposed to the entry of the government into power, fertilizer, or other business, perhaps even including barge line operation. But those acquainted with his record and activities believe that he is unalterably opposed to all these government activities.

Certainly there remains no one now able to rally back of this Valley Authority idea anything like the large number of diverse groups which President Roosevelt did bring together to back his favorite concept of government handling many affairs in such organizations.

TVA SET BACK

WHILE MVA advocates are having their troubles in getting any favorable congressional consideration, the parent valley authority, "Yardstick" TVA, is also in trouble. It has lost a number of important staff members. Its chairman David Lilienthal is vigorously opposed for reappointment by congressional critics. And the appropriations committee of Congress has refused to reappropriate $3,000,000 for the phosphorus plant at Mobile. TVA got that money about three years ago but has not been able to spend it because it could not get priorities for needed equipment and scarce construction materials.

CENSUS PLANS MADE

A COMPLETE census will be taken of all manufacturing industry beginning next January. The investigation will cover the manufacturing operations of the calendar year 1945.

A comprehensive reclassification of industry has been made by Central Statistical Board which now governs the classification of manufacture both for Social Security Board and Census purposes. Gradually all other agencies of the government are reorganizing their statistical work to conform to this classification. Thus the data from various bureaus will become comparable for the first time, it is hoped.

The Census inquiries for chemical enterprise will give more attention to commodity data than formerly. It is hoped that a very complete report can be had on the production of every individual chemical and other product of chemical engineering enterprise. Much more data will be gathered regarding the raw materials consumed in making these products. Exact plans are not yet completed because the amount of money and staff available is not yet definitely known; but it appear that a much more comprehensive study will be made than has been possible for quite a number of years.

The last previous Census of Manufactures was taken in 1940, covering the operations of 1939. It is expected that the job done next year will be much more complex unless Congress demands unexpected economies. If so, the inquiry forms and schedules now being prepared will have to be cut back to much simpler forms than are now in the works.

BASING POINT BAN

PRICING of commodities with the use of a single basing point for freight charges, in which some fictional rather than actual place of shipment is assumed, constitutes unlawful discrimination among customers. This in effect is the finding of the U. S. Supreme Court on April 23 in the case where Corn Products Refining Co. was under attack by Federal Trade Commission. In this and a similar case involving A. E. Staley Manufacturing Co., the court ruled in a manner that seems to eliminate much of the basing point price practice of several industries.

The charge here was that by using an assumed point of shipment, rather than the actual one, the companies had unfairly and unlawfully established different prices for corn sirup. The discrimination violated the Clayton Act and the Robinson-Patman law which provide for equal treatment of customers of like sort who are themselves competitors. Numerous industries may have to revise their basing point price systems as the government proceeds to apply this final court decision.

SYNTHETIC VS. NATURAL

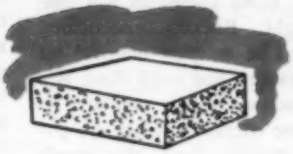
THE PROMISE to Chile that Uncle Sam would not operate government-owned synthetic ammonia plants except for war purposes stirred a lot of comment. The State Department was basing this promise to leave American markets open for natural Chilean nitrate on a more general pledge made in 1942. That earlier promise was resolution No. IX adopted by the conference of Ministers of Foreign Affairs of the American Republics meeting at Rio de Janeiro during January 1942. That resolution cited "emergency industries which under normal circumstances would be considered as uneconomic" and closed with the following:

"Resolved: That the nations of the Americas stimulate the development of the basic production of each of them, avoiding insofar as possible the establishment or expansion of production of substitute or synthetic commodities which is economically artificial and might displace the consumption of natural products available

how TO BUILD AN ACID-PROOF FLOOR THAT WILL STAND UP EVEN UNDER ABNORMAL CONDITIONS

THE PROBLEMS involved in corrosion-resistant floor construction are so many and so varied that it is small wonder that such floors are a source of so much trouble to engineers and maintenance men alike.

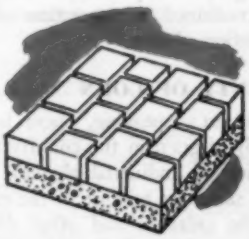
The procedure outlined below, based on our experience of 80 years in handling corrosive problems, will give a floor of proven durability and economy — a floor that will stand up not only under traffic loads, but under exposure to oil, water, acids, alkalies, and solvents and is reasonably resistant to thermal and impact shock.



1st Start with a rigid, solid base. The ideal base is rigid concrete, 3" to 4" thick, even thicker, if traffic conditions are severe.

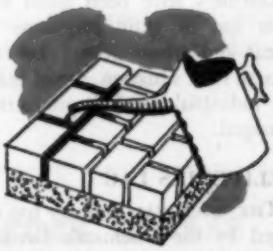
2nd Cover the concrete base with several layers of tar paper. All posts, curbs, drains, etc., should be carefully flashed in—just as carefully, in fact, as if you were preparing a roof.

3rd Mop the entire area with either U. S. Stoneware's Resilon or U. S. Stoneware's Calktite. Both are applied hot (about 200°F). Don't be stingy, use plenty of Resilon or Calktite. Cover the entire area to a depth of approximately ⅛". Remember, this membrane is designed to prevent sub-surface seepage. Prepare it carefully.



4th Lay the floor with "U. S." Acid-proof Ceramic or Carbon Brick*, allowing ¼" joint space between the brick, and place the roughened non-skid surface out. Thickness of the brick depends on traffic conditions—for light traffic the minimum should be 1⅛", for heavy duty traffic 2¼". It is rare that more than one course is required.

**Carbon brick if hydrofluoric acid is present. Some sacrifice in wearing qualities must be anticipated.*



5th Bond the acid-proof brick with a good sulphur-base cement such as Portite, Super-Portite, or Carbo-Portite, by pouring the cement (hot) into the joints. If a sulphur-base cement will not resist the particular corrosive conditions in your plant, fill the joints only to within ⅜" or ½" of the top, then point the joints with Durisite, an acid, alkali and solvent-resistant resinous cement.

It is important to remember that even with time-proven design, the ultimate life of the floor depends on: (1) careful workmanship, and (2) the best materials. The U. S. Stoneware products recommended for use: "U. S." Acid-proof ceramic or carbon brick, Resilon, Calktite, the Portite series of sulphur-base cements, and Durisite acid-and-alkali-resistant resinous cements, are recognized as tops in their respective fields by chemical engineers everywhere. They are backed by a reputation built through 80 years of service to the chemical and allied industries. All materials mentioned are available for immediate shipment.

If you will send us your floor measurements with information regarding corrosive and service conditions, we will be glad to recommend the specific materials best suited and enumerate the items required.

U. S. STONEWARE

Since 1865 • Akron, Ohio

in other American nations, there being excepted only those industries which are indispensable for national defense provided that such defense needs cannot be effectively met with natural products."

That resolution attracted no attention when released to the press in February 1942. Hence our diplomats argue that they are justified in basing on it a new pledge not to use war facilities in peacetime, because this has become an accepted policy of the United States.

Opposition has been kept quiet in Washington because of the San Francisco conference. Nevertheless, it is not expected that Congress or the President will support any extreme restrictions of this sort when actual postwar settlement of the fate of synthetic industry must be arranged. Such settlement will not come without controversy by the ultra-internationalists. But much of the new development made during the war period will unquestionably be continued in operation despite this resolution of Rio.

PLENTY OF CORN

BROADLY speaking, there is an ample supply of grain in the country for the production of industrial alcohol. There are local shortages because of the car shortages on the railroads and other difficulties of transportation. Relaxation of the order against the purchase of high moisture grades of corn for drying and storage for later use was made only when nothing further could be done about forcing the immediate use of wet corn. Restrictions have been removed on the extent to which distillers may dry corn after purchase.

Distillers have been asked to continue their use of grain sorghums to replace wheat and wheat grits. In view of the over-all food situation, use of milling grains for industrial alcohol production is discouraged.

DELIVERIES LAG

THE CHEMICAL industry has again been urged by the Chemicals Division of the War Production Board to place orders for maintenance, repair and operating supplies as early as possible. At the present time, delivery on nickel is from 9 to 10 months and stainless steel from 11 to 12 months.

Wholesale cancellations of military orders could change the picture rapidly if the cuts were deep enough. The industry is advised that a pessimistic view of this possibility is the safest at this time. Last fall when there were expectations of wholesale cancellations the cuts did not materialize. The country is entering another similar period of expectation which may fool the unwary.

CONTROLS TO CONTINUE

ALLOCATION of certain chemicals after V-E Day as forecast by WPB Chairman J. A. Krug has little meaning for the chemical industry. Of the approximately 125 chemicals controlled by order M-300, only 10 or 15 can be completely relaxed following the end of European hostilities.

One of the 12 steps in the Victory-in-Europe program for the reconversion of the national economy from wartime controls was the continuation of specialized control over all materials in tight supply. Tin, crude rubber, textiles, lumber and certain chemicals were placed in this category by Krug when he announced his program which was to assure that all essential war and civilian needs would be met.

Chemical allocations under M-300 are perfectly flexible. The allocations are reviewed monthly under normal procedure, but there is nothing that would prevent their being changed weekly if conditions should change that fast.

Cutbacks must be very considerable before they will be felt in a better supply of chemicals. Until TNT requirements are reduced greatly, heavy chemicals will continue to be tight. Rockets, insecticides, etc., continue to be in great demand for the Pacific operations and until there is a substantial reduction in the military requirements, those chemicals which are giving the most trouble from the supply side will continue to do so. In addition to the heavy chemicals, this category includes the solvents and material used by the protective coating industry for military finishes. Although cutbacks have already started in the chemical industry, it will be some time before industry feels them.

TRADE DATA RELEASED

PROGRESS of the war has permitted release of practically all foreign trade statistics which have been withheld for military security reasons. On May 1 the data regarding imports and exports in the calendar year 1942 were made available for general use. On July 1 there will be comparable release of foreign trade data of 1943. The exact date for release of 1944 trade statistics has not yet been announced.

MINOR NEWS GLIMPSES

Stainless steel has been redefined by WPB as "heat or corrosion resisting steel containing 4 percent or more of chromium with or without nickel, molybdenum or other elements." Thus the government definition is very much broader than the same term commonly used by chemical engineers and metallurgists. When dealing with WPB this fact must be clearly understood or misunderstanding is likely.

Canadian manufacturers will have their military contracts cut back at the same rate as American producers of similar war goods. WPB takes trouble to announce this fact as an offset for the criticism which started when big purchases of aluminum were made in Canada while government-owned plants in the United States were idle or running far below capacity. The aluminum experience was painful, and it is not going to be typical if Chairman Krug has his way.

Considerable steel has been released for box-car building. Thus ODT again emphasizes the serious scarcity of freight cars to be expected during the coming year. Anyone to whom the car problem is serious can safely start worrying now. They will have to sooner or later.

Liquefied petroleum gases are not as abundant now as expected by PAW a few months ago. The pressure for more butane continues both for aviation gasoline and synthetic rubber making. Those who would like this gas as a special fuel are to do without it for many months more.

Cylinder supply and transport is now the major bottleneck limiting chlorine usage for a number of industries. There is no surplus of chlorine anywhere, but many would-be users could be better served if transport in cylinders could be augmented. Some less essential users near points of generation are getting gas while more essential users at remote locations do without.

Cadmium plating for corrosion resistance is further restricted by new orders of WPB. A purchaser of cadmium-plated products must now certify a specific permitted end use in order to secure the products coated with this metal.

"Period One" is the name given in Washington to the time between victory in Europe and victory over Japan. During that interval a new set of allocations for all classes of claimants and claimant agencies will be applied by WPB. The Requirements Committee asked that all estimates be revised on the assumption that V-E Day would occur on or before June 30. Thus the beginning of reconversion is speeded.

Civilian goods supply will reach prewar levels before the end of 12 months after Germany's defeat. Thus Chairman Krug of WPB forecasts the speed of restoration of goods manufacture. No one knows better than Krug that generalizations of this sort cannot be applied to many specific commodities. But at least the general estimate gives industry something of a formal official guess from which to formulate its own specific estimates.

National Planning Association released during April a very comprehensive summary entitled "Fertilizers In The Postwar National Economy." This booklet presents a national policy for fertilizer prepared by a special committee representing many points of view. It appears to represent a more nearly sound workable program than any of the partisan groups have offered. Up to May 1 no one has undertaken to put this plan into legislative form for Congress.

DOW CORNING

SILICONES

DOW CORNING, first in silicones, is fully equipped with new plant and facilities for the production and distribution of an expanding line of silicone products

American industry has been quick to utilize the new Dow Corning Silicones—to see the potentialities inherent in their higher order of heat stability, chemical inertness, water resistance, and dielectric properties. Dow Corning is now supplying, directly or through selected distributors, the following silicone products:

DC FLUIDS Water-white, odorless, inert Silicone Liquids . . . notable for their low rate of viscosity change over a wide temperature range, low vapor pressure, water repellency, and good dielectric properties.

DC 4 Ignition Sealing Compound . . . an easily applied silicone waterproofing compound having excellent dielectric properties, corona resistance, and the consistency of petroleum jelly. It neither hardens nor melts at temperatures ranging from −40° F. to 400° F.

DC 7 Special Low Temperature Compound . . . an oxidation resistant lubricant and sealing compound developed for use at temperatures as low as −70° F.

DC 31 A lubricating Silicone Grease for special applications in the temperature range of −70° F. to 190° F.

DC 41 A lubricating Silicone Grease for special applications where operating temperatures range from 0° F. to 400° F.

DC 993 Insulating Varnish . . . recommended because of its extreme heat stability for impregnating, coating and bonding, and waterproofing inorganic insulating materials such as asbestos, mica, and Fiberglas cloth, tape, and sleeving. Other special purpose silicone resins and compounds are available.

DC STOPCOCK GREASE A chemically resistant Silicone Grease for lubricating stopcocks and other ground glass joints.

DC PLUG COCK GREASE A Silicone Grease that affords easy operation of lubricated plug valves over wide temperature ranges in most difficult services.

Dow Corning

FIRST IN SILICONES

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
ADDRESS ALL INQUIRIES TO BOX 592

INTERPRETATIONS

This installment covers orders, rules and regulations issued by the War Production Board and the Office of Price Administration during April, 1945. Copies of each item interpreted here may be obtained from the appropriate federal agency.

GELATIN STOCK

A NEW requirement, effective April 25, directs all purchasers of wet gelatin raw stock to weigh each shipment immediately upon its receipt. This action provides a check to determine the actual shrinkage in all shipments and is designed to prevent sellers from exceeding their legal ceilings through practices that would cause excessive shrinkage such as the addition of water to the wet gelatin stock.

NAPHTHENATES

MILITARY requirements for naphthenic acid and naphthenates have increased to such an extent that use of these chemicals has been further restricted. Beginning with the June allocations, use of naphthenate driers for all military paints is prohibited with the exception of specifications AN-TT-P-656b and USA 3-201, both of these referring to zinc chromate primers.

ALKYD RESINS

EFFECTIVE April 4, an amendment to the schedule of M-300 which affects phthalic alkyd resins, requires users of coatings conforming to Specifications 3-171 and 3-173 to purchase grade 11 coatings containing semi-alkyd if they have facilities either to bake such coatings for 45 minutes at 200 deg. F. or for shorter periods of time at higher temperatures.

It further provides that grade 1 coatings of Specification 3-67F, made without alkyd resins must be used by those who have baking facilities. A special form of certification must be used by those who do not have baking facilities. Use of alkyd resins also is denied to the U. S. Maritime Commission on Specification 52-MC-30, and all contractors are instructed to substitute coatings made under other appropriate Maritime Commission specifications.

RECLAIMED RUBBER

THE Rubber Bureau of WPB has amended R-1 to further limit inventories of reclaimed rubber. Users of reclaimed may now carry a 45-day supply instead of a 90-day stock as heretofore. A maximum of 60-day supply is permitted for aqueous dispersions of reclaimed rubber, the liquid types that the manufacturing industry frequently mixes with natural and synthetic latex. Previously these had not been under inventory control. Permitted inventories of natural rubber, natural latex and all types of synthetic rubber are continued at the 60-day level and chlorinated rubber at the 30-day level.

CHROME PIGMENTS

IT HAS been announced officially that manufacturers of Class A chrome pigments will receive in May approximately 60 percent of their requirements of sodium bichromate for the manufacture of the pigments controlled by Order M-370. This cut in allocation of bichromate will reduce the pigment supply to a like extent. The pigments affected are chrome yellows and oranges, chrome greens, molybdated chrome oranges and hydrated chromium oxide.

Small order exemptions for Class B will be entirely eliminated in May as no allocations are made for such distribution. Hence, manufacturers must file Form WPB-2945 to acquire less than 25 lb. of chrome oxide or 50 lb. of zinc chromate for military use. Continued shortage of chrome chemicals and increased military demands for the pigments made this action necessary.

LEAD CHEMICALS

WHILE Order M-384, governing the use of lead chemicals, prohibits the use of lead for art pottery and decorative ceramics, WPB will consider requests from manufacturers for the use of lead and lead chemicals held in the inventories of such producers as of March 27, 1945. Such appeals should be filed in accordance with the provisions of Order M-384.

PHTHALIC ANHYDRIDE

PHTHALIC anhydride continues to be one of the most critical raw materials in the war production program. Production is expected to increase in the coming months but the additional output will be reserved for the production of dibutyl phthalate for smokeless powder and dimethyl phthalate for the manufacture of insect repellants. The movement of larger forces to the Far East war area is expected to increase demand for phthalic anhydride for insect repellants. Prospects are not favorable for an increase in production of maleic anhydride.

STEARIC ACID

BECAUSE of short supplies, the War Food Administration has issued an order to regulate distribution and use of stearic acid. The order also limits inventories of distributors and users and requires producers to set aside a portion of their monthly output for specific authorizations. A group of certified uses has been set up and suppliers must fill these requirements before accepting orders for less essential uses. Certified uses are manufacture of metallic stearates, except for use in cosmetics and toiletries; rubber compounding; manufacture of lubricants and greases; manufacture of pharmaceuticals and medicinal preparations other than cosmetics and toiletries; and any use certified by the administrator of WFO 129 and bearing an authorization number.

ANIMAL OILS

TO BRING about a more even distribution of animal and neat's foot oils, inventories of distributors and consumers have been limited by an order which went into effect on April 1. Distributors of these oils are restricted to a supply equivalent to one-third of their deliveries during the last six months of 1944. Users of animal oil may maintain inventories equal to a 60-day supply or 60,000 lb. whichever is greater and users of neat's foot oil may hold a 60-day supply or 30,000 lb. whichever is greater. Producers of these oils are required to report within 15 days after the end of each calendar month, their actual production and deliveries for the month, their month-end stocks, and their estimated production and deliveries for the succeeding month.

PHENOLIC RESIN

AN amendment to Schedule 87 of M-300 directs that all resins containing paratertiary butyl phenol be classified as Coating Resin A. Formerly only resins containing 10 percent or more of paratertiary butyl phenol were included in this classification. Military requirements for resorcinol resins have grown so these resins also have been made subject to the directives of Schedule 87.

PRICE REGULATIONS

ONLY three grades of Congo copal gum are currently available and they have been placed under ceiling prices of $225, $170, and $155 respectively for numbers 1, 2, and 3. The prices refer to metric tons fob Matadi, Belgian Congo. Ceilings for the same grades of natural resins were increased at the same time.

Some manufacturers of household soaps and cleaners find it impossible to continue production of certain items unless ceiling prices are increased. A new adjustment provision enables them to apply for increases in their present ceilings.

Higher than normal costs for rubber grades of channel carbon black may be passed on by producers and their distributors when selling small quantities they have bought from the Defense Supplies Corp. pool.

Importers of carnauba wax have favored higher maximum prices as a means of increasing offerings from primary markets. On April 20, OPA issued a statement to effect that prices would not be advanced as foreign supply was too small to be influenced by a change in price.

SUSTAINED CONSTRUCTION ACTIVITY

One Step Toward High Level Employment

IN the 34th editorial of this series, it was pointed out that sustained prosperity, based on high level employment, was a major postwar goal accepted by government, management and labor.

That editorial developed the theme that, if the goal were to be approached without undue sacrifice of our essential liberties, we must forego the search for magic panaceas, and follow the harder but more promising course of analyzing step by step, and industry by industry, the measures that might contribute toward the end sought.

This is the first of a number of editorials following such a particularized approach. It will examine the role of the construction industry in forwarding sustained prosperity.

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The influence of construction upon the general level of economic activity is important but not decisive. The claim is frequently advanced that major fluctuations of the business cycle might be ironed out by a properly devised and timed public works program; but any examination of the relatively modest contribution of construction activities to total national output will demonstrate its extravagance.

In the twenty years from 1920 through 1939, the value of new construction averaged just over 8½% of the gross national product. If we add repair and maintenance expenditures, the total is increased to a little over 12% of the gross product. But approximately two thirds of the construction of this period was privately initiated, and only one third was represented by government construction, federal, state and local combined. To expect that we can level out the peaks and valleys of our whole economy through manipulating the 4% portion that is represented by government construction is to expect a very small tail to wag a very large dog.

In fact, the record of construction activity in the past has been on the side of disequilibrium rather than stabilization. In boom times construction activity has climbed to relatively higher peaks than those reached by the economy as a whole; in depression periods it has fallen to deeper troughs. Aside from the special work relief program of the depression thirties, the performance of public construction in this respect is little better than that of private. New government construction mounted with the general trend of the boom from 1921 to 1929, thereby adding its weight to the inflationary trend.

Instead, then, of expecting the construction industry to stabilize our whole economy—a task clearly beyond its power—it would seem appropriate to ask that it look to the more attainable goal of leveling out its own violent fluctuations. If this can be done, many of the most vexing problems of the construction field and of its sphere of influence will be mitigated, employment will be regularized in one important segment of industry where the past record has been particularly uneven, and one aggravating contribution to general business instability will be removed.

The achievement of these highly important, if limited, aims will require the thoughtful, vigorous, and concerted cooperation of management and labor in the construction industry, of a variety of governmental agencies, and of those who direct the sources of construction credit. Of the many measures that must be woven into an ordered program, it is practicable here to present only the broad outline of those which seem to offer the greatest potential usefulness.

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1. Stabilization implies the holding of a balance rather than a freezing at a given level. No rigid formula for a most desirable level of construction activity is possible or desirable. However, it may be accepted as a reasonable initial premise, that we could sustain in the future without major distortion something like the 12% ratio of total construction to gross national product that has been approximated in the past. If it is to serve as an useful reference point, such a generalized premise must be subjected to constant testing both nationally and locally. There must be careful and continuous scrutiny for signs of demand saturation, cost inflation, and labor shortages, all danger signals of far greater reliability than any percentage formula.

The first requisite then is the general availability of information along such lines, far more complete and current than has hitherto been at hand. The second is a general will to hold building activity at a level as high as but not higher than we probably can sustain. Once this principle is accepted, the problem becomes one of marshalling all available instrumentalities to forward it.

2. Public construction, although too small to exert a decisive influence upon economic activity as a whole, can

condition construction trends to a major degree. If, in the decade following the war, government construction approximates its 1920 to 1940 average of one third of all construction, its properly timed impact could do much to level out the construction cycle.

To do this most effectively, public construction should be deferred where and when private building is going forward at a satisfactory pace, and should be started when and where private activity shows undue slack. All government construction does not lend itself to such adjustment. But a large portion of it could be held up for the three to five years which, upon past experience, would provide the necessary leeway to counteract the more violent fluctuations in private building.

Such a program presents numerous difficulties both political and administrative. None should be insurmountable, and the results promise to be of sufficient moment to justify the extraordinary effort that would be required to coordinate federal, state and local government programs. Here is an excellent forum for testing whether or not government economic activity can be made to supplement rather than supplant private effort to serve ends upon which all are agreed.

3. Since private building, postwar as in the past, must supply the preponderant share of construction activity and employment, costs will continue to play a dominant role in determining levels of operation. Wartime restrictions have created formidable backlogs of deferred demand for most types of private, and for many of public, construction. Such demand is so great that it almost certainly will provide the impetus for a postwar building boom of several years duration. There is considerable doubt that in the beginning our building trades, dislocated by war and at low ebb, can organize rapidly enough to carry their share of the anticipated general advance.

However, if former patterns hold, building activity, after a lagging start, will soar, costs will mount, and eventually will saturate effective demand with resultant collapse. That, of course, is precisely the sort of a situation we are seeking to avoid. Crucial to this end is the prevention of rising costs or, better still, the reduction of building costs from present swollen levels.

A recent study by technicians of the War Production Board on the outlook for private housing construction illustrates the point. From 1900 to 1940 the number of housing units built in this country closely matched the statistics of new family formation. The former ran considerably ahead of the latter from 1920 to 1929, and fell behind by the same margin in the following decade.

If the market for new houses were to be similarly limited for the period from 1940 through 1949, the effective demand for new housing during the last five years (1945-1949) is estimated at 3,000,000 units. That is after allowing for houses built from 1940 through 1944, and for vacancies, demolitions, and other factors. If, however, prices could be reduced to 1939 levels, the 3,000,000 unit demand is estimated as increasing to more than 7,000,000 units. Since the latter figure is substantially beyond our production capacity for the period, a backlog would be created that would support an effective sustained demand for the subsequent decade (1950-1959) of 1,000,000 units per year, as against half that amount if rents and sales prices mount with increasing incomes.

The precise accuracy of such an estimate may well be questioned. There can be no question as to the general validity of the point illustrated. The progressive lowering of construction costs will stimulate demand in this field as it has in others. Building management, labor, and their suppliers and customers stand to gain from such a result. Unnecessary restrictions against the adoption of improved technologies and increased productivity should, therefore, be removed, whether imposed by codes of government, regulations of unions, collusion of managements, or inertia of workers. Unless there are compelling social justifications such restrictions must be judged harmful to the whole economy.

4. Numerous other measures could contribute substantially to increased and increasingly stable construction activities. Space remains only to stress the importance of careful consideration for the use of credit facilities as a means of stabilization. In recent years the establishment of the Federal Housing Administration provided a needed stimulus to mortgage lending in the field of housing. The modern pattern of long-term mortgages, providing for regular amortization as well as interest, should be a steadying factor in periods of liquidation. However, there appear to be further possibilities for using credit facilities as a brake when construction activity threatens to climb beyond a level that can be sustained. If public and private lending agencies could devise sound means for raising mortgage rates, increasing down-payment requirements, shortening amortization periods and basing value appraisals upon normal rather than inflated costs, they might exert a healthy influence against the tendency of the construction bubble to inflate until it bursts.

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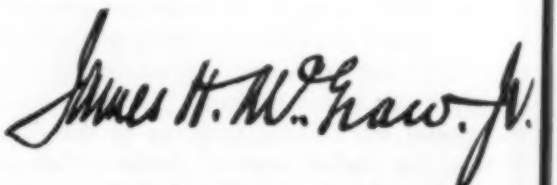
There is no royal road to sustained high level employment. There is not even a single path to assured construction stability—there are many paths, all strait and narrow and all paved with bruising cobbles. This is true for all other major segments of industry.

It is easier to seize upon a magic formula such as monetary control, or deficit spending, or any one of a score of others, than to undertake an intricate task of piecemeal exploration. But only the latter course will lead to prosperity.



President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 35TH OF A SERIES

CHEMICAL
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MAY 1945

The Clock Strikes Twelve

BACK in February 1934 in an editorial commenting on the death in exile of Professor Fritz Haber, we included this rather reckless statement: "Such is the sad commentary on an ungrateful government. The closing days of a life that probably contributed more to the practical advance of German science, agriculture and industry than any other, must be spent in exile while a flamboyant corporal struts his hour upon the German stage." Those words immediately got us into trouble. *Chem. & Met.* was banned from Germany by official decree. A few Nazi sympathizers posing as friends and good American citizens urged that we apologize in the interests of amicable relations between the two great chemical countries of the world. Their advice was unheeded although we did try (in vain) to disassociate science and industry from the fanaticism of the German government.

The great clock has ticked all too slowly, these past eleven years. In fact there were times when its hands seemed to spin backwards as the Hitler hordes swept as a holocaust over most of Europe. Eventually, of course, their direction was reversed and for many months now it has been certain that the long awaited hour would soon arrive. Even as these words are being written, here in London in late April, preparations are being made for the glad day when the chimes of Big Ben will sound the notes of exultation that will forever echo in the hearts of free men all over the world.

Meanwhile many of us are seriously concerned with the problems of peace, more particularly with the constructive use that can be made of the war-born advances of German science and industry. There is no disagreement on the score of their immediate application in finishing the job that Japan started December 7, 1941. Nor can we see any moral reason why our peacetime industries should not be permitted to share equitably in the information being obtained from captured plants and laboratories of the enemy. We are not seeking reparations in money, goods or land. But what we can obtain in the way of new science and technology, processes, patents and know-how, can be used by the democracies in building a better and safer world.

That is our objective. We cannot reach it unless we approach the job with only the broadest national interests before us. There is no place for self-seeking or selfish schemes to obtain commercial advantages for individuals, companies or nations. All that our military and technical investigators uncover in their strenuous work behind the lines in Germany is already being shared with our Allies. That cooperation must continue until the job is done and the detailed reports are written, published and widely distributed. Only in that way can we make sure that the results of our work can find their proper utilization.

This is the job that begins in earnest as the clock strikes Hitler's doom. It is extremely complicated and difficult. We are going to make mistakes in typically American fashion, we are going to rush in from many directions with duplicating and overlapping agencies and missions. But our objective is clear and a great opportunity for public service is at hand. As technical men we owe it to the American people to help make certain that the German war machine is beaten into plowshares with which to cultivate the fields of peaceful reconstruction.

Sidney D. Kirkpatrick

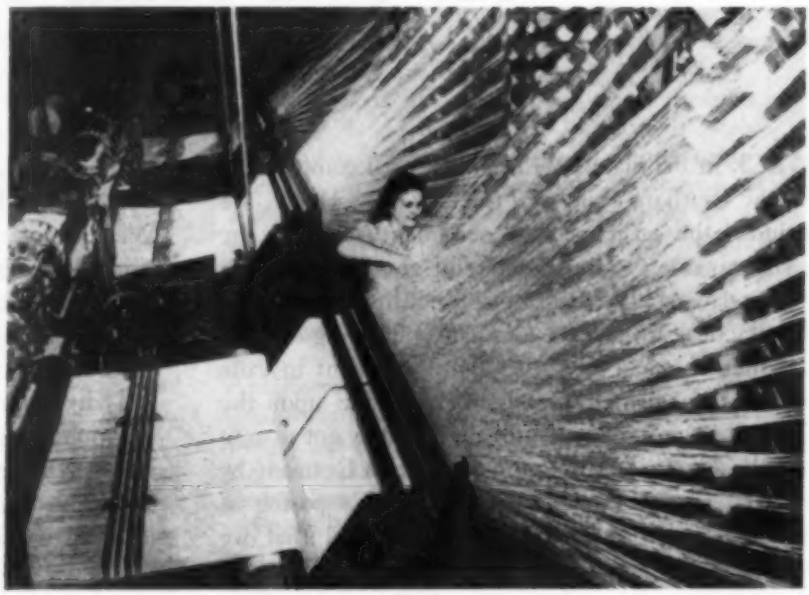
London
April 20, 1945

HOWARD H. IRVIN *Chemical Engineer, E. Chicago, Ind.*

NYLON POLYAMIDES

Their Chemical and Industrial Development

High polymer chemistry, lusty infant of industry, represents one of the highest accomplishments of chemical research and engineering. By the same token, complete success in the field is difficult, results often pleasingly unpredictable. Within the past decade, polymer research has been intensified, yet nylon still represents probably the outstanding jackpot in the field. Here is one of the most complete stories on development of polyamides of the nylon type. — *Editors*



Nylon's strength, elasticity and light weight are among its features

DURING the last 25 years great progress has been made in the field of high polymer chemistry, which up to that time had been badly neglected. To differentiate between the different types of synthetic polymers it is helpful to divide them into two groups: (1) those resulting from additional polymerization; (2) those obtained by poly-condensation.

Addition polymerization is characterized by the linking of a large number of simple, unsaturated molecules either alike or varying in composition (co-polymerization), to form long-chain or three-dimensional networks of essentially saturated molecules. This is usually accomplished after activation of the monomer by a catalyst, the growth of such chains being very rapid once activation has taken place. Of the many synthetic polymers produced today, GR-S synthetic rubber, polystyrene and other vinyl polymers are typical examples of addition polymerization.

Poly-condensation, on the other hand, shows more resemblance to reactions of classical chemistry. Here, simple molecules condense with each other by interaction of functional groups. These groups, such as —OH, —COOH, —NH_2, of which each simple molecule must at least have two, interact with each other to form links between the monomers, eliminating at the same time such simple molecules as H_2O:

$$n\mathrm{HO{-}R{-}\overset{\overset{O}{\|}}{C}{-}OH} \rightarrow \mathrm{HO(-R-\overset{\overset{O}{\|}}{C}-O-)_nH} + (n-1)\,H_2O$$

The mechanism of poly-condensation does not differ greatly in this respect from ordinary esterification reactions. The earlier products made commercially by this type of polymerization were phenol-formaldehyde, urea, and alkyd resins.

Systematic investigation of poly-condensation reactions was not carried out until W. H. Carothers started his work which led to the development of polyamides of the nylon type, the first truly synthetic fibers. Fibers made by the regeneration or modification of cellulose are not truly synthetic since the cellulose itself is already a polymer.

In the late 1920's research was undertaken to overcome some of the shortcomings of these cellulose derivatives (6). This work, consisting mainly of finding new modifications of cellulose esters and ethers, did not lead to very promising results.

PIONEER CAROTHERS

At about that time, under the guidance of Carothers, fundamental research on poly-condensation reactions was initiated. Ten years later a commercial synthetic fiber was on the market which, under the name of "nylon," has proved to be as good and in many respects better than its natural competitors. The name nylon was chosen to designate "generically the synthetic fiber-forming polymeric amides, having a protein-like structure from which the new product is formed."

Carothers began his work by investigating condensation of glycols with carbonic and dicarboxylic acids (9, 11, 12, 17, 18, 21). It was found that condensation which leads to five and six-membered rings always remained intermolecular, while molecules that would form larger rings give both monomolecular rings and linear polymers (15). Work was concentrated on these linear polymers of molecular weights ranging from 800-5,000. These α-polyesters of

relatively low molecular weight were termed α-esters. They were mostly microcrystalline powders of low melting point and good solubility.

Late in 1930 attention was called to the self-condensation of ε-amino caproic acid. This amino acid formed both a 7-membered lactam ring (20-30 percent) and a linear polyamide (80-70 percent) when heated (11). The polymer and lactam were readily separated from each other. The polymer was a hard, gray wax, insoluble in most organic solvents except hot formamide, from which it separated as a microcrystalline powder of high melting point (212-214 deg. C.). Molecular weights were in the range of 800-1,000 corresponding to the relatively low degree of polymerization of about 10.

THE MOLECULAR STILL

It became evident to Carothers that it would be necessary to achieve a higher degree of polymerization in order to produce useful materials. The answer was found in the molecular still (14). This apparatus had been originated in the early 1920's and was originally used in Germany for the purification of mercury. It was further developed in England (7) and in this country (41). Until a few years ago this still was just a laboratory curiosity but it is now used commercially on an increasing scale (33).

Since the condensation reactions studied by Carothers depended on the elimination of simple molecules in the progress of the reaction, it was believed that these condensations would be forced to completion by removing the volatile, simple molecules from the reaction mixture as fast as they were formed. The idea was to apply the principles of the molecular still "to instances in which the effective vapor pressure or escaping tendency of a volatile product was very small." Experiments carried out on the basis of these ideas were successful, and a patent was issued which claims the following conditions as necessary for the successful operation of the molecular still (19):

(1) The reaction mixture must be maintained at a temperature at which the rate of the reaction is appreciable and the volatile product to be removed has a significant vapor pressure, (10^{-3}mm. or higher);
(2) The condenser which retains the volatile product must be kept at a temperature at which the condensate has a negligible vapor pressure;
(3) Pressure in the system must be sufficiently low to render the "mean free path" of the distilling molecules equal to or greater than the distance from the evaporating surface to the condenser, the "mean free path" being the distance traveled by a molecule between successive collisions with other molecules.

The first ester distilled by Carothers in the molecular still was the trimethylene ester of hexadecamethylene dicarboxylic acid. The α-polyester was heated in the still for 12 days at 200 deg. C. No condensate was collected after the first 7 days. The viscosity of the molten polyester increased progressively to 12,000. The same procedure was followed with other α-esters such as ethylene succinates and sebacates (15).

These polyesters of molecular weight above 5,000 were called ω-esters. Such esters from dicarboxylic acid and glycols, resulting in formation of progressively longer chains by intermolecular coupling, showed colloidal behavior and simulated to a remarkable degree some of the properties of natural occuring high polymers (see TableI).

Table I—Properties of Polyesters from Trimethylene Glycol and Hexadecamethylene Dicarboxylic Acid[15]

	α-Ester	ω-Ester
Apparent molecular weight	3,000	12,000
At 100 deg. C.	viscous liquid	soft, sticky resin.
At room temp.	white, opaque brittle wax	cream-colored, horny opaque elastic.
Melting point, deg. C.	75-76	transparent at 75 but does not flow.
Solubility	very sol. in cold chloroform	swells in cold chloroform, then dissolves.

This change from a low molecular weight polymer to one of very high molecular weight changed the properties of the polyester to a remarkable degree. X-ray patterns showed crystalline structure, but there was no sign of any general orientation. But when cold drawn, tough, pliable, elastic and highly oriented fibers were obtained (13, 19, 20). However, filaments produced without stress were so fragile that they could not be bent without breaking.

Rough determinations of the tensile strength on rather thick fibers of the ω-ester gave values of 24-36,000 lb. per sq.in., which are fair as compared to cotton fibers. Carothers pictured perfectly oriented fibers as consisting essentially of a single crystal in which the long molecules are in ordered array parallel with the fiber axis. The fiber strength, depending on the molecular length, would make necessary a molecular weight of at least 12,000 and a molecular length of at least 1,000 Å to produce a strong, pliable, useful fiber.

Results obtained by the poly-condensation of dicarboxylic acids and glycols were very encouraging (18) but two factors made these fibers unsuitable for commercial exploitation: (1) their relatively low melting point and (2) their solubility in a great number of solvents. Work carried out with the linear polyamides of ε-amino caproic acid showed that these were harder, tougher and much less soluble than the corresponding super-polyesters. This was attributed mainly to the higher molecular cohesion of the —CONH— group.

The procedure for preparing these polyamides has been described as follows (22): 7.2g. of ethyl 6-amino caproate was heated at 170-180 deg. C. for 4.5 hr. Approximately 1.5g. of ethanol distilled off. The polymer was not spinnable. It was then heated 18 hr. at 220-240 deg. C. below 1 mm. pressure. 2g. of lactam was collected as a distillate during the heating under reduced pressure. The super-polymer finally obtained had a melting point of 200-203 deg. C. and was readily spinnable.

Since neither these polamides nor the polyesters alone showed properties desirable for a useful fiber, an attempt was made to prepare mixed polyester-polyamides and thus combine the promising properties of both (16). These compounds were obtained by heating trimethylene glycol hexadecamethylene dicarboxylic acid and ε-amino caproic acid for about 3 hr. in an inert atmosphere at 200-220 deg. C. and then for 5 hr. at 1 mm. pressure at 250-260 deg. C. The viscous residues were transferred to the molecular still for three days at 200 deg. C., but only a small amount of cyclic lactam was removed in the still.

The products were opaque to translucent solids which were hard, tough, and in thin sections flexible and elastic. As the proportion of amino acid was increased, the polymer would increase in brittleness, hardness, transparency and melting point. Brittle and opaque filaments were obtained by touching a specimen with a glass rod and drawing the rod away. By warming to 40-50 deg. C. these filaments could be drawn out into transparent fibers which were pliable and stronger than those obtained from the ω-polyesters. It was concluded that these materials were still not good enough to compete with natural fibers.

COMMERCIAL SUCCESS

When, after a critical review of previous results, work was again resumed, Carothers turned to the preparation of other polyamides. The polyamide from 9-aminononanoic acid gave fibers with a melting point of 195 deg. C. which, after cold drawing, were equal to silk in strength and pliability (6). Then, instead of using amino acids as starting materials, Carothers prepared a number of polyamides through the condensation of diamines with carboxylic acids (23). A number were prepared with melting points ranging from 170 to 280 deg. C. (see Table II).

Table II—Melting Points of Polyamides—Polyamide Derivation

	Melting Point, Deg. C.
Ethylene diamine and sebacic acid	254
Propylene diamine and sebacic acid	220
Tetramethylene diamine and adipic acid	278
Pentamethylene diamine and adipic acid	195
Pentamethylene diamine and dodecamethylene dicarboxylic acid	170
Hexamethylene diamine and sebacic acid	209
Hexamethylene diamine and adipic acid	263
Octomethylene diamine and sebacic acid	197

No strict rule seems to cover the variation of melting points, but generally these decrease with an increase in unit length of the hydrocarbon chain and with substitu-

tion. The polyamide from hexamethylene diamine and adipic acid, first synthesized in February 1935, was considered the most promising, both from a standpoint of its properties and the possibility of manufacture on a commercial scale.

Work for the commercial exploitation of this new fiber material was started without delay. Little information is available on this part of the work, but the patent literature does reveal a fairly clear picture (23, 24, 25, 26). The reaction in making hexamethylene adipamide polymer may be shown in the following way:

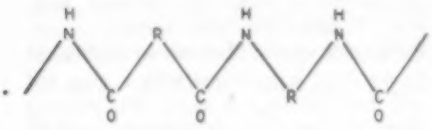
$$n\,H_2N(CH_2)_6NH_2 + n\,HOOC(CH_2)_4COOH \longrightarrow$$

Hexamethylene diamine adipic acid

$$\ldots\ldots NH(CH_2)_6NH\text{-}\overset{O}{\overset{\|}{C}}\text{-}(CH_2)_4\text{-}\overset{O}{\overset{\|}{C}}\text{-}NH(CH_2)_6NH\ldots\ldots + (n-1)H_2O$$

Polyamide

Amino groups of the amine and carboxyl groups of the acid interact, forming long chains by elimination of water and formation of multiple peptide linkages. The structural formula of this polymer re-



sembles natural fibers like wool and silk to a remarkable degree. Since both the amine and the acid contain six carbon atoms in the molecule, the polymer was identified as polymer "66."

BUILDING BLOCKS FOR "66"

Production of the "building stones" of polymer "66" was an important factor in deciding which polyamide could be manufactured most economically. Both adipic acid and hexamethylene diamine can be made from the same raw material, benzene. This is converted to phenol, which is then hydrogenated to cyclohexanol which, upon removal of one mol of hydrogen, gives cyclohexanone. Oxidation of the cyclohexanone splits the ring, yielding adipic acid.

Hexamethylene diamine can be made from adipic acid by reaction with ammonia to adipamide which, upon dehydration, yields adiponitrile. In the last step, adiponitrile is hydrogenated to give tetramethylene diamine. Thus the two monomers for polymer "66" can be obtained by reactions which have been known for many years.

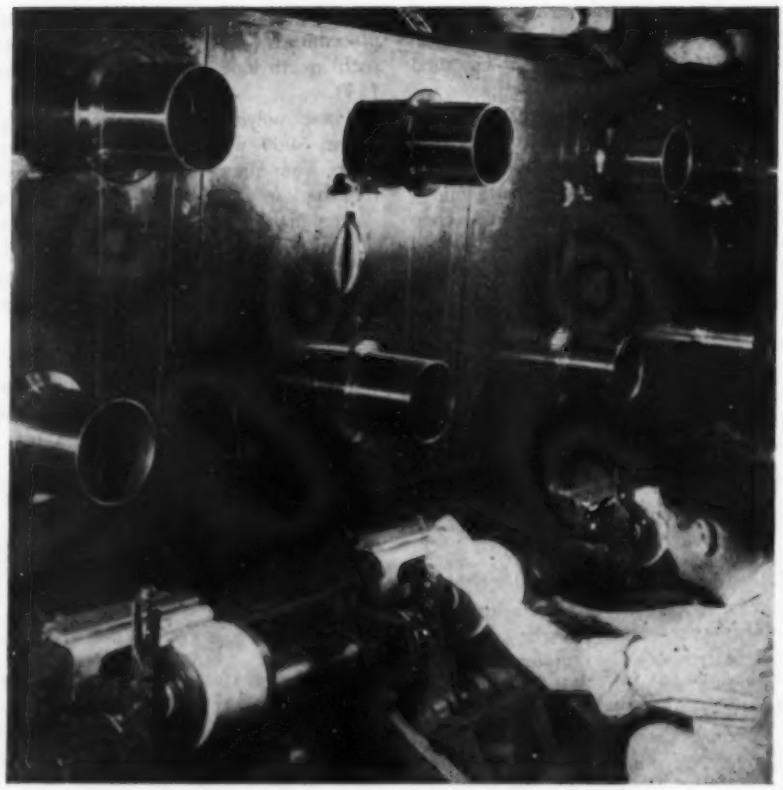
Now let us look closer at the actual reaction. In one of the patents (24) two factors are emphasized: (1) necessity for purity of the raw materials and (2) their presence in proper proportion during the reaction. A way was found which greatly simplified the task of obtaining the reactants in the right proportions. When acid or amine is placed in water and the other component added, an inflection in the pH curve results at the point where both reagents are present in equivalent amounts. Measuring the pH with glass and calomel electrodes, the following values at the inflection point were determined:

Pentamethylene diamine and sebacic acid	7.50
Hexamethylene diamine and adipic acid	7.63
p-xylene diamine and sebacic acid	7.03

To these water solutions, viscosity stabilizers may be added and the water distilled off. The residue can then be heated to reaction temperatures under the proper conditions. However, instead of preparing the polyamide directly from the diamine and dicarboxylic acid, it was advantageous to prepare and isolate the diamine dicarboxylic acid salt as an intermediate in the polyamide formation. This avoids the difficulty of preserving isolated amines in a state of purity and tends to eliminate impurities in the starting materials. Incidentally, the pH of solutions of these salts coincides very closely with the inflection point previously mentioned.

Hexamethylene diammonium adipate is conveniently prepared in hot ethanol by mixing solutions of the diamine with approximately an equivalent amount of the acid and adjusting to the inflection point (24):

A mixture of 144 parts of hexamethylene diamine, 174 parts adipic acid, 1,300 parts 95 percent ethanol, and 210 parts of water are warmed until complete solution is obtained. The mixture is then cooled, which causes separation of the less soluble salt in the form of white crystals. The salt is separated by filtration and recrystallized from 1,300 parts of 95 percent ethanol and 200 parts of water, yielding 247 parts of the pure salt with a melting point of 183–184 deg. C.



Nylon yarn, after the fine filaments extruded from the spinneret have been brought together, is wound on bobbins

This salt formation is apparently used in the commercial process (6). Another patent (25) describes preparation of the fiber-forming polyamide from the salt, which may be carried out by reacting the salt in bulk, in a solvent or in a non-solvent. In the first method, the salt may be heated in absence of both a solvent or diluent to 180-300 deg. C. under conditions permitting removal of the water formed:

Two mols of hexamethylene-diamine-adipamide and 0.02 mols adipic acid (viscosity stabilizer) are placed in a 2 L. silver-lined autoclave, equipped with a stainless steel stirrer and reflux condenser. The air is removed by evacuation, filled with nitrogen, and again evacuated. Then 80 lb. per sq. in. nitrogen pressure is put on the autoclave, the stirrer started and the temperature raised to 288 deg. C. over a period of 1.5 hr. Pressure is decreased during 30 min. to atmospheric pressure, and heating and stirring continued for 2.5 hr. longer. Then the pressure is decreased to 200 mm. for several minutes. After cooling the polymer is removed from the autoclave as a white solid.

The salt may also be heated in an inert solvent for the polymer, such as cresol, phenol, xylenol or diphenyl-propane. When the reaction has proceeded far enough to give a polymer of good fiber quality, the mixture can be removed from the reaction vessel and used as such for spinning or the polymer can be separated by precipitation with a non-solvent.

Third, the salt may be reacted in the presence of an inert non-solvent for the polymer, such as high-boiling hydrocarbons. Exclusion of air during the reaction is im-

portant to prevent oxidation, which causes discoloration of the product. In general, no catalysts are needed for the reaction. However, the surface of the reaction vessel has some catalytic action and sometimes catalysts such as oxides, carbonates, or stannous chloride are beneficial.

Commercially, polymer "66" is apparently manufactured without any solvent or diluent, the above example providing a good idea of the process most likely used. In 1939, a patent (26) was granted for preparation of light-colored polyamides in reactors suitable for large scale production. The reactors are constructed of or lined with silver, tantalum, chromium plate, or chromium-containing ferrous metals and are used under oxygen-free conditions.

Commercial nitrogen, containing as little as 0.05 percent oxygen, is unsatisfactory for use in these reactions. The oxygen content must be brought to less than 0.03 percent. This can be done by washing commercial nitrogen with a sodium bisulphite solution.

In 1944, a patent (38) was granted to carry out these reactions in a continuous process, which would be a step forward over the original batch method. By this new process, polyamides can be prepared by continuously passing an aqueous solution of a diamine dicarboxylic acid salt at super-atmospheric pressure through several reaction chambers at the temperature for polyamide formation. A great deal of work has doubtless been done to develop the batch process into a continuous operation. Just how successful the attempts have really been is not known.

In the commercial process (5, 6, 31) the molten polymer, after being discharged from the reactor, is extruded as a ribbon onto a chilled roll and cut into small chips. In this form the polymer is completely stable. It has a crystalline structure and a melting point of 488 deg. F. It can be stored in granular form, known as "flake," for further processing. In the extrusion, the flake is charged into a hopper of the spinning unit, dropped to a heated grid where the polymer melts, and after metering and filtering is extruded into filaments. During this process the polymer is surrounded by an inert gas to avoid oxidation. The filaments harden and are wound on bobbins at a speed of about 2,500 ft. per min. They are then cold drawn. This operation causes the molecules, which had essentially a random distribution, to orient themselves. A relatively small force is required to produce a four-fold increase in length.

PROPERTIES OF NYLON

Many articles have been published which give the chemical and physical properties of nylon and compare nylon fibers to silk, cotton and rayon (1, 2, 3, 5, 6, 31, 32, 34, 39, 40). It may be well to summarize some of these items for the reader.

Nylon has only moderate resistance towards mineral acids and strong oxidizing agents, but it is practically inert against alkalis, aliphatic, aromatic and halogenated hydrocarbons, organic acids, ketones, alcohols and carbon bisulphide. Solvents include phenol, cresol, cresylic acid, formic acid and xylenol.

Boiling in 5 percent hydrochloric acid causes brittleness and ultimate disintegration. Nylon is rapidly disintegrated by cold concentrated nitric acid, while 10 percent sodium hydroxide at 85 deg. C. for 16 hr. does not harm it (3).

Melting point of nylon "66" is 253 deg. C. The density as compared to other yarns is quite low:

Nylon 66	1.14
Silk	1.30
Viscose rayon	1.52
Acetate rayon	1.30

At present (3), two kinds of nylon yarn are known to be manufactured: standard and high tenacity. Standard yarns have a tenacity of 4.5-4.8 g. per denier and an elongation of 18-22 percent before breaking. High tenacity yarns have a tenacity of 6.0-7.0 g. per denier and an elongation of 11-17 percent before breaking. All nylon yarns have a definite stretch recovery and compare in this respect somewhat to rubber yarns, yet they do not stretch as easily and as far and recovery is very slow as compared to the instant recovery of rubber.

Nylon has a higher tenacity than silk. This point is emphasized by the fact that the wet strength is about 88 percent compared to the very pronounced weakening of other fibers:

	Tenacity, G. per Denier	
	Dry	Wet
Nylon 66	5	4.5
Silk	4.6	3.9
Viscose rayon	1.8	0.9
Acetate rayon	1.5	1.0

Water absorption of nylon fiber is also comparatively low:

	Relative Humidity		
	60%	75%	100%
Absorption, %	3.5	4.7	7–8

These values compare very favorably with the water absorption of other fiber materials (at 60 percent relative humidity):

	Absorption, Percent
Nylon 66	3.5
Silk	11
Wool	13
Viscose rayon	12
Acetate rayon	6.5

Considering all the data, it can well be understood why nylon has become a very strong competitor for silk. Of course the supply of raw silk was cut off at the outbreak of war, but nylon was ready at the time to fill this gap. Today all nylon produced is used for important military items such as parachute fabrics and shroud lines, powder bags, as a substitute for natural bristle and many other items which there is no need to mention here.

Polymer "66" is still the most widely used variation of nylon, ten types of which are made today (5). Nylon has been suggested as a molding powder (4) and as insulation for wire and cable. While it has undoubtedly found application in special formulations for both these purposes, it is handicapped by a relatively high cost in comparison with a large number of synthetic resins which have proved their value in these fields.

But let us not forget that the polyamides have only made their debut as new synthetic resins of industrial importance. Since the first patents were granted to Carothers, many new developments have been announced both here and abroad (27, 28, 29, 30, 35, 36, 37). Whitby, in a survey of polymerization (42), points out a few of the large number of ways to modify polyamides.

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G. BOSSCHIETER *Advisor to the Netherlands Economic Mission*

NETHERLANDS

Chemical Industry Looks to Postwar

With the European war over, a period opens with greater opportunities than ever before for trade and manufacturing relations with Holland and the East Indies. The prewar facts about the process industries and plans for expansion are discussed by Dr. Bosschieter, chief chemist for an Amsterdam paint manufacturer when he came to this country on business in 1940. After Holland was invaded he joined Dow Chemical Co. and in 1943 was called to his present position.—*Editors*

PLANNING for a redistribution of European industry, and more in particular for the building of new industries in Holland and its overseas territories, needs to be based on knowledge of both the prewar situation and the present status. In order to facilitate an investigation of the postwar outlook for trade and manufacturing in the Netherlands Kingdom, a condensation is given of the most important data concerning the chemical industry, as published in various Dutch publications. Most of the figures are for the year 1938, which can be considered a relatively prosperous year of the Netherlands Kingdom. Naturally, this survey of the prewar Dutch chemical industries is far from complete and covers only the more important activities.

Only in some instances is reference made to the present situation in Holland and the East Indies because most of these territories are still in enemy hands. Not until the entire liberation, when the full extent of physical destruction can be known, will it be possible to describe the magnitude of the tremendous problem of industrial rehabilitation and reconstruction.

Mineral resources of the Netherlands proper are very limited and consist primarily of coal and salt. However, considerable contribution to the economic wealth of the Indies is derived from its sub-soil. Before the war oil and tin were on the average second and fourth in value on the list of exports, rubber being first.

Coal is mined in southern parts of the Netherlands and the 1938 output amounted to 13.5 million tons.* The foreign trade in coal for the same year is listed as import 4.9 million tons and export 3.4 million tons. The coke production amounted to 3.8 million tons in Holland and 4.4 million tons in Belgium. However, Holland exported most of its coke output, while Belgium with its large iron industry exported only 25 percent in the last years before the war.

Coal is plentiful in the Indies, although of rather inferior quality. In 1940 more than 2 million tons were mined and exports were made to other Far Eastern countries. Extensive experimental work has been carried out in an effort to produce metallurgical coke from Netherlands East Indian coal. All these attempts, however, failed completely and this contributed to the absence of an iron and steel industry. Some coke is imported yearly, mainly for the small foundries and the lime kilns of the sugar industry.

The salt deposits in the Netherlands have been exploited since the early thirties and the output has been steadily increased from 75,000 tons in 1934 to more than 200,000 tons in the last year before the war. Salt in the Indies is produced from seawater, mainly on the island of Madoera (141,000 tons in 1939) and in various other locations (18,000 tons.).

The East Indies supplied 60.4 million barrels of oil in 1940. Bauxite operations, started in 1933, provided for 275,000 tons in 1940 and plans for the establishment of an aluminum plant had been worked out before the Japanese invasion. Alum was made in the Indies after the start of this war and utilized for water purification, etc.

Manganese deposits gave a high [illegible] ore (production 12,000 tons in 1940). [illegible] utilized locally for manganese dioxide production for batteries. Many other minerals are found, some of which have a definite future. Sulphur is present in crater deposits and the 1940 production amounted to 17,200 tons. Calcium and aluminum phosphates have been found and are used as fertilizers (the 1939 output amounted to 18,800 tons with a phosphoric acid content of 30 to 40 percent).

The West Indies have fewer domestic resources. Surinam's mineral resources consist of bauxite and gold, while the island of Curacao has phosphate of lime (exports in 1941 exceeded 100,000 tons).

HEAVY CHEMICALS

The restricted domestic mineral resources and the absence of natural power have not prevented the development of a Netherlands inorganic chemical industry. Raw materials have been imported from all parts of the world and the processing industries contributed substantially to the Netherlands export trade.

Sulphuric acid is one of the most important chemicals manufactured in the Netherlands. Consumption of this acid is indicated by the 1938 net import plus domestic production, totalling 673,000 short tons. The annual production has increased steadily since the last war and the 1938 output was 578,000 short tons. Imports, consisting mainly of diluted impure acid, came chiefly from Belgium (143,000 tons in 1938), while exports of concentrated acid went largely to the Netherlands West Indies to be used for petroleum refining.

The upward trend in the Dutch production was mainly due to the heavy demand for manufactured fertilizers. By far the largest consumers are the superphosphate and ammonia sulphate plants, while the rayon industry is an important consumer of the strong acid. Of interest is a comparison between the percentage consumption figures for Holland and this country. The predominant position of the fertilizer industry among the Dutch chem-

* All tons are metric (2,204.62 lb.) unless otherwise specified.

ical industries is clearly demonstrated by the following figures indicating the percentages of the total sulphuric acid consumption as used by the fertilizer industry: Holland (1938) 90.5 percent, Belgium (1939) 55 percent, U. S. A. (1940) 24.7 percent.

All raw materials for sulphuric acid production have to be imported and their relative importance is demonstrated by figures for the year 1938: pyrites 384,000 long tons (mainly from Spain), zinc ore 44,000 long tons. Sulphur, in contrast to U. S. practice is not used in Holland for acid. A small amount of acid is made from spent oxide from the gas plants and imports Great Britain.

the ten sulphuric acid plants, three are using the contract process. One company manufactures this acid as its main product, while the remaining plants are part of the fertilizer industry. The closing down of the superphosphate plants after the invasion caused a drastic cut in the production. In addition, the chamber plants were stripped of their lead by the enemy. The roasted pyrites, which are used in Holland only to a small extent, were exported mainly to Germany.

U. S. Exports to Holland in 1938

Coal tar colors	$120,000
Misc. organic chemicals and other chem. specialties	470,000
Bor[illegible]	199,000
[illegible]n black	174,000
[illegible]n fertilizers	329,000
[illegible]phate rock	769,000
[illegible]let soaps and dental creams	204,000

U. S. Imports From Holland in 1938

Creosote oil	$742,000
Quinine sulphate	390,000
Quinine alkaloids	336,000
Industrial chemicals	103,000
Barytes ore	96,000
Lithopone	196,000
Ammonium sulphate	1,473,000
Other nitrogen fertilizers	302,000
Phosphate fertilizer	123,000
Gelatine	369,000
Potato starch	146,000
Dextrine	120,000
Cyanides	124,000
Pharmaceuticals	99,000

Hydrochloric acid consumption increased considerably during the last years before the war due to the establishment of a modern tin smelter in Holland. The prewar (1938) production amounted to around 5,000 short tons by salt electrolysis and 13,000 by the salt cake process. Substantial imports (12,500 short tons in 1938) from Belgium and Germany were necessary in order to cover the domestic requirements.

Since the war the consumption decreased drastically in the absence of tin ore and this resulted in 1942 even in a net export. The salt cake production was stopped by the Germans, necessitating increased imports of salt cake from Germany. Before the war salt cake was exported (in 1938 some 5,200 tons went to the U. S. A.).

Nitric and phosphoric acid are produced by the fertilizer plants, which will be discussed hereafter. Some imports of nitric acid (2,000 short tons in 1938) were still necessary.

The exploitation of the salt deposits in the Netherlands resulted in the establishment of a modern alkali industry. About 35 percent of the total salt consumption is utilized in the processing industry. For 1938 the following data in short tons are listed:

Crude salt imports	111,000
Crude salt production	180,000
Crude salt consumption	68,000
Refined salt production	221,000
Refined salt consumption	68,000
Refined salt exports	102,000

Salt electrolysis provided for around 6,000 short tons of caustic soda in 1938 and the production since then has been considerably increased. The simultaneously produced chlorine is partly used for the production of bleaching powder, bleaching lye, muriatic acid, etc. In general the home production was insufficient to cover the domestic requirements and large imports of alkali chemicals were necessary, such as 15,000 short tons of caustic, chiefly from France.

Holland has been dependent on imports of soda ash from foreign sources. With the availability of raw materials for soda ash production, it can be foreseen that after the war the existing plans for a soda plant will materialize and this should reduce the annual imports, which amounted to 60,000 tons. Several factories make sal soda from imported product. The main utilization of soda ash is in the soap and glass industries.

Among the other alkali products of the Netherlands is waterglass, which is used largely by the important export industry of strawboard. Prewar potash production from molasses amounted to about 3,500 tons. Potassium salts are further imported and used for electrolysis and fertilizers.

Early in 1940 a carbide plant came into operation for the production of calcium cyanamide (capacity 30,000 to 40,000 tons of carbide annually). Another Dutch industry manufactures cyanides and ferrocyanides, of which the United States imported in 1937 and 1938 respectively 2.2 and 1.4 million pounds.

There is no independent heavy chemical industry in the East or West Indies. The Netherlands East Indies petroleum refineries produced annually around 50,000 short tons of sulphuric acid by the contact process from volcanic sulphur. Their imports of caustic soda amounted in 1939 to 20,500 short tons, which came during the last years before the war almost entirely from the United States. With large quantities of sufficiently pure salt available establishment of a caustic plant forms part of the industrialization plan of the Indies. Soda ash came largely from Japan, but plans had been worked out for a soda plant on Java. Electrolytic chlorine will provide for hydrochloric acid, which in turn will be used for the treatment of natural aluminum phosphate.

CHEMICAL FERTILIZERS

The importance of the synthetic fertilizer industry has already been stressed. The superphosphate industry forms a striking example of industrial development in a country largely dependent on imports of raw materials. Although all the crude phosphate had to be imported, Holland was in the early thirties the largest superphosphate exporter of the world. An overall picture of this industry is given by the following figures in short tons for 1938:

	Import	Export	Production
Crude phosphate	479,000	22,000	0
Superphosphate	64,000	488,000	645,000
Other phosphate fertilizers	15,000	41,000	73,000
Basic slag	464,000	24,000	0

After the German invasion this highly important industry came to a standstill. The lack of phosphates has reduced greatly the productivity of Dutch farm lands.

Dutch agriculture calls for large volumes of fertilizers. Since 1929, three nitrogen fixation plants with a combined capacity of 135,000 short tons of nitrogen were put in operation. The table below gives production and trade data in short tons for 1938:

	Production	Import	Export
Ammonium sulphate (20.6% N)	325,000	0	245,000
Lime-ammonium nitrate (20.5% N)	175,000	81,000	1,000
Calcium nitrate (15.5% N)	59,000	2,000	4,000
Calcium cyanamide (20.5% N)	0	36,000	0
Sodium nitrate (15.5% N)	0	73,000	0

Mention has already been made of the establishment of a cyanamide plant with an annual capacity of about 25,000 tons. In 1938, Holland exported to the United States 38,300 short tons of ammonium sulphate. About one-fifth of the ammonium sulphate output is produced as a byproduct from the coke ovens and gas plants, while the remainder is manufactured by the ammonia plants. Since 1933 the production of lime-ammonium nitrate has increased in importance.

No potassium fertilizers are manufactured in Holland. Basic slag accounted in 1938 for more than half of the Dutch calcium requirements and lime-ammonium nitrate for nearly one-fourth. Direct calcium fertilizer needs can be filled by local resources of marl and other calcium substances.

Fertilizers are among the most important chemical imports to the East Indies. In 1939, 109,000 short tons of ammonium sulphate, 49,000 tons of other fertilizers and 5,000 tons of superphosphate were imported. Ammonium sulphate is the most suitable fertilizer for the East Indian agriculture and just before the war a nitrogen fixation plant with an annual capacity of 40,000 tons ammonium sulphate was ordered. Natural gas, found at several locations on Java, offers good possibilities as

a source of supply of hydrogen for ammonia synthesis, while domestic sulphur can be used for sulphuric acid production. An ammonia plant on Java would further satisfy the needs of ammonia for rubber latex conservation, cooling purposes, explosives manufacture for mining, etc.

ORGANIC CHEMICALS

The Netherlands organic chemical industry is far less developed than the inorganic industry despite the fact that coal tar crudes are available locally. The coal tar production at the coke ovens and gas plants amounted in 1938 to 180,000 short tons. About 50 percent of the output is utilized as pitch for coal briquettes. The production of benzol was estimated at 25,000 to 30,000 tons. In 1938 the export of the principal coal tar products in short tons amounted to: benzol, 20,600; toluol and xylol, 3,900; naphthalene, 4,800; anthracene oil, 3,500; creosote oil, 42,700; and miscellaneous, 9,200. The United States imported from Holland creosote oil and naphthalene, while the light oils went mainly to Germany and France.

The small production of coal tar intermediates is related to the limited size of the dyestuff industry (two plants manufacturing mainly sulphur dyes) and to the absence of a synthetic resin industry (plastic articles were made from imported resins). The dyestuff requirements of the important textile industry had to be covered by imports of 5 to 6 million pounds annually, of which Germany supplied more than 50 percent, the share of both the U. S. and Switzerland being around 10 percent. Dye imports into the East Indies amounted to about the same volume and are used in the indigenous batik industry, replacing almost entirely the old vegetable dyes. With the collapse of the dominant position of the German chemical industry it can be foreseen that substantially increased imports of fine chemicals will have to be made from this country. Also increased attention can be expected to be given to the production of intermediates and coal tar derivatives.

FERMENTATION INDUSTRIES

Few data are available on the prewar production of the various organic chemicals produced in Holland. The fermentation industries provide for alcohol, ether, yeast and solvents. Acetic acid is produced by fermentation, but predominantly by synthetical methods. Of the other organic acids may be mentioned formic, citric and lactic. Detergents and other chemicals were made for the important textile industry. The pharmaceutical requirements were covered to a great extent by imports of semi-finished and finished chemicals. The most important class of domestically produced medicines are the alkaloids, of which quinine is most important. Other alkaloids, such as cocaine, theobromine (made from cacao-scale waste from the Dutch cacao industry) had also found an export market. Since 1935 the domestic production of enzymes practically covered the local demands. An important hormone production was established in the Netherlands as an accessory to the large Dutch meat packing industry. Synthetic hormones and hormone extracts were manufactured largely from domestic raw materials and partly from imported glands. For the insulin production, which was the largest in Europe, domestic pancreas supplies became insufficient and additional quantities had to be imported from the western hemisphere. The principal vitamins were produced in Holland from domestic and imported raw materials. Sulfa drugs were both made in Holland and imported.

CHEMURGIC INDUSTRIES

Dutch agriculture provides raw materials for many industries processing farm products such as sugar beets, potatoes, and straw. It is beyond the scope of this article to go over all these processing industries. Several commodities, like potato starch and strawboard, enjoyed an export market and large quantities of chemurgic raw materials were also imported. As an oustanding example of industrial enterprise and trade in a country having such limited domestic resources, mention is made here only of the oilseed crushing and vegetable oil processing industry.

American exporters of linseed oil cake have for many years found an excellent market in the Netherlands. Necessary protective measures for the Dutch industry, however, caused a strong reduction in these imports. At the same time exports of vegetable oils to the U. S. have increased since 1934. The table below gives an overall picture of the prewar foreign trade (all figures in million pounds):

	1933	1934	1936	1938
Import oil seeds	1,160	1,584	1,472	1,540
Import oil cake and meal	744	323	288	370
Export oil cake and meal	81	20	13	9
Export vegetable oils	275	359	332	376

There are 29 vegetable oil plants in Holland with an annual oil capacity of about 770 million pounds, compared with the U. S. production in 1938 and 1944 of respectively 3 and 4 billion pounds. The main part of the oil is produced from imported seeds, while oil from domestic raw materials is negligible. Around 10 percent of the processing capacity consists of extraction plants.

Refining to edible oil is carried out in four large plants and a few smaller ones with a combined capacity of 500 million pounds, while the hydrogen capacity is estimated at about 330 million.

Large consumers of vegetable oils in Holland are the margarine industry (14 plants), the soap industry (56 plants), and the paint industry. Margarine exports fell sharply in the early thirties, the production amounting to 157 million pounds in 1938, whereas the prewar soap production exceeded 200 million pounds.

Rayon is an important chemical export industry in the Netherlands. The Dutch viscose rayon production at the outbreak of hostilities amounted to 33 million pounds per year. There are three rayon plants in Holland. The main raw materials are imported and 70 percent of the finished product was exported. Since the war, the rayon output has been boosted considerably and production of staple fiber was initiated. Since 1937 casein has been tried out in Holland as a raw material for synthetic fiber production.

Holland has been in the past essentially a paint exporting country. Most of the raw materials for the protective coating and ink industry, however, must be imported. Only few pigments were produced and the estimated annual prewar production of the principal pigments was: zinc white, 20 million pounds; lithopone, 40 million pounds; white lead, 4 million pounds.

Lithopone exports to the U. S. accounted in 1938 for 7.7 million pounds. Crude zinc oxide and barium sulphate were imported chiefly from Germany. During the last five years before the war, rapidly increasing amounts of synthetic and modified natural resins were consumed by this branch of industry. The high price of the imported products greatly restricted their utilization and after the war domestic production of varnish resins on a sufficient scale can be visualized, while imports will shift to those basic chemicals not manufactured within the country.

Domestic lime marl and slag from the blast furnaces are utilized by two cement plants with a combined capacity of about 600,000 tons, which is more than half of the total prewar consumption. The Dutch lime requirements, however, are to be covered largely by imports. Most of the domestic lime is derived from sea shells.

Finally, the resources of the overseas territories were the origin of several manufacturing industries in Holland, such, for example, as those for essential oils and perfumes.

In conclusion, it can be said that despite the lack of domestic raw materials and power, Holland's chemical industry had reached a remarkable degree of development. The geographical location of the Kingdom does not lend itself to the building of so-called "insurance plants." The international orientation of the Netherlands however, gave rise to an important transshipment trade and enhanced the steady growth of processing industries. The tremendous needs for the rebuilding of Europe offer many new possibilities for industrial development within the Netherlands and increased industrialization is also likely to occur in the Far Eastern territories.

Chem. & Met. reports on . . .

Continuous Processing

Never before in the forty-odd years that *Chem. & Met.* has been published has there been so much interest as there is today in the possibilities for "continuizing" chemical engineering processes that are now operated on a batch basis. On that account, no time seems better than the present for an examination of just what continuous processing means to chemical engineering.

Perhaps the most important conclusion of this study is that continuous processing is in no sense an over-all panacea. Putting a process on a continuous basis is not necessarily the path to greatest efficiency—in fact, it may be quite the reverse. Some processes are clearcut for batch, some for continuous processing or for some combination of the two. With others, however, the best choice may be a difficult one to make.

Our problem then is to look at some of the determining factors, economic and technical; to see how processes have already "gone continuous;" to examine continuous process types, their peculiarities, their design problems. Then, to gage the trend, we have assembled a group of articles on individual industries in which the prospects for continuous processing are assayed.

CONTINUOUS FLOW PROCESSES—AN INTRODUCTION

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IN INVITING a group of engineers to discuss various aspects of the subject of this symposium, *Chem. & Met.*'s editors posed the proposition that a definite trend was evident toward continuous processing in chemical and other process industries, and that the trend was likely to accelerate in the postwar decade. There is, indeed, such a trend and it may go far, but it is by no means so universal nor so compelling as some people believe. There has been a good deal of careless thinking in the past concerning the relative merits of batch and continuous processing and the idea has grown up among many engineers who have not had occasion to think the matter through that continuous processing is inherently and necessarily more efficient than batch. Actually, this is not the case since neither type of processing is inherently bad, and neither inherently good.

Some types of process are better when conducted batchwise and others better continuous. Many are more efficient when they contain both batch and continuous steps. Sometimes the determining factors are economic, sometimes technical, and frequently both. Usually it is only by a complete engineering analysis in a given case, comparing batch and continuous processing, and various combinations of the two, that a reliable guide to the best possible decision can be obtained. Fortunately, the technical data needed can be obtained by either batch or continuous experiments, whichever are more convenient. Subject to certain rules the information may be used interchangeably for comparing batch, semi-continuous and continuous commercial processes.

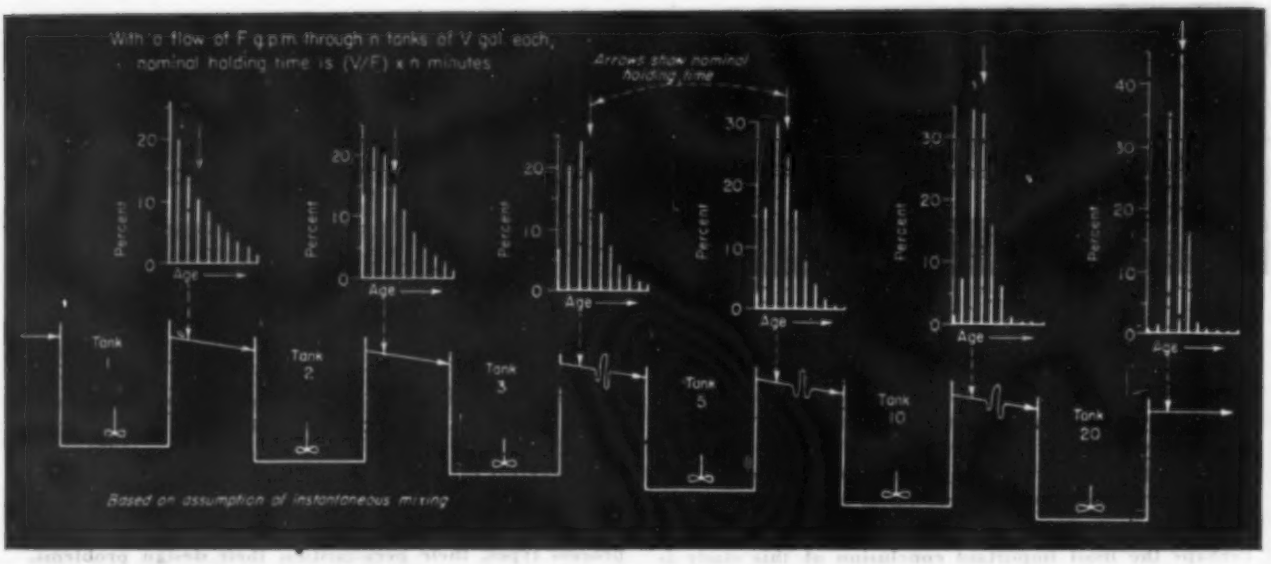
A continuous process is usually defined as one in which all process variables remain constant with time at a given point in the flow path, but vary with distance along the path. This definition applies not only to complete processes but also to the individual steps of the process, such as chemical changes, physical changes and the transfer of materials and of heat.

DEGREES OF CONTINUITY

There are many gradations in the continuity of a given series of processing steps, as well as in the individual unit operations and the unit processes which comprise them. In the ideal condition of continuity, there is no mixing along the axis of the path, but virtually perfect mixing normal to the axis. Moreover, conditions change in a continuous manner along the axis, rather than by a series of discontinuities. In practice, ideal continuity is never attained.

If we list a few variations in order of increasing continuity, at one extreme is the process that consists entirely of batch steps. Following this is another containing both batch and continuous steps, tied together with provisions for "surge volume" to iron out the discontinuities. The next gradation is a process that simulates continuity through the use of several overlapping batch steps feeding one or more continuous steps. Still more nearly continuous are the processes having a constant flow of a fluid through a series of vessels in which the fluid is contacted with a solid that is renewed batchwise. In this case the vessels are cut out of the line one at a time when exhausted, and returned when replenished, producing a countercurrent effect. Examples of this type are numerous in "diffusion" and extraction batteries, in adsorption processes, and in vapor phase catalytic reactions using a fixed solid catalyst which requires periodic regeneration.

Such processes as those mentioned are essentially batch in character, even though some may bear a similarity to continuous processes. It is not until an approach to true continuity is attempted that the situation is likely to become complex from a theoretical standpoint. This complexity may not apply to all types of process, but it does apply to those in which mixing is depended upon for the establishment of a proper process "environment" or where agitation is used as an aid to the diffusion of material or the convection of heat. Mixing is a random operation, the results of which are affected both by the design of the equipment and by the laws of probability. If a continuous process is carried out in a single agitated tank, it is obvious that various portions of the outflow will have remained in the tank for varying lengths of time. Even if it be assumed that the inflow mixes instantly and perfectly with itself and with the entire tank contents (which is not far from true when only a single fluid phase is involved), it is still clear that part of the inflow will short-circuit and pass almost immediately to the outlet, other parts will remain for increasingly longer periods, and an infinitesimal part will (theoretically) never leave. However, if the same tank volume is then divided between two


With a flow of F g.p.m. through n tanks of V gal. each, nominal holding time is (V/F) x n minutes
Arrows show nominal holding time
Percent
Age
Tank 1
Tank 2
Tank 3
Tank 5
Tank 10
Tank 20
Based on assumption of instantaneous mixing

Bar charts between tanks show how increasing the number of series tanks averages the retention time

or more tanks in series, an averaging takes place and the greater the number of tanks, the closer the approach will be to a single average "age" or retention time in the system for each portion of the outflow.

Probably Ham and Coe[1] were the first to apply mathematical analysis to continuous flow through one or more tanks in series. The bar charts between tanks in the accompanying diagram show approximately how the "ages" or retention times of the various parts of the outflow from tanks 1, 2, 3, 5, 10 and 20 in a series vary, and emphasize how increasing the number of tanks tends to bring all parts of the outflow to a uniform retention time.*

EFFECTS OF NON-UNIFORMITY

Since various parts of the flow in a continuous system of series tanks remain in the system for different times, the treatment accomplished in the system cannot be uniform for all parts of the flow. How serious this will be depends on what the relation between *result* and *time* may be for the particular process considered. Most processes advance at progressively slower rates as completion is approached, since the driving force usually decreases with time. For example, heating rate decreases as the heated body approaches the temperature of the hot source; solution rate of a dissolving solid decreases as the solid surface decreases and as the concentration of the resulting solution approaches the saturation limit; and reactions proceed at rates that are proportional to the amount of the reactants still unreacted, thereby falling off toward zero rate as the reaction approaches completion.

If we know what the driving force is in any given case, it is possible to express the relation between result and time mathematically, by the aid of empirically derived constants. Having this relation, we can then consider what the effect of carrying out the process on a continuous flow basis will be. If it is performed under stated conditions in a batch tank, the result of the process will be the same theoretically for every portion of the batch, since each portion will have undergone treatment for the same length of time. However, when the process is carried out continuously in a series of tanks having the same overall nominal holding time as the batch equipment, the average result on the various portions of flow cannot be the same as that of the batch process, unless the process happens to be one that is linear with time. (This condition, met in so-called zero order reactions, is theoretical only, although it is approached in some reactions such as the cracking of petroleum and the copolymerization of butadiene and styrene for GR-S rubber manufacture. Such processes tend to be particularly well suited to continuous operation). Since rates of completion of most processes decrease with time, those portions of the flow that are held longer than the average retention time, and so are overtreated, are unable to offset the undertreated portions which are held less than the average time.

This makes it clear that a continuous process in series tanks cannot be as efficient from a time-volume standpoint as a batch process conducted under the same reaction conditions, although continuous process efficiency will approach that of batch processing as the volume of the reaction system is subdivided into greater and greater numbers of stages. Furthermore, the comparison with batch efficiency becomes less favorable as the kinetic order† of the reaction and the required reaction completion increase. This is true because higher order reactions fall off in rate more rapidly as they approach completion than lower order processes. Hence, greater subdivision of the tank volume is required and continuous processes for reactions of second or third order, or higher, become difficult to justify unless there are special circumstances that demand them.**

The facts that have already been considered suggest the desirability of developing ideal "streamlined" continuous reactors in which all material will advance through the process at the same rate and hence give the same time efficiency as a batch process. A concept of such a reactor can be developed as follows: Consider a finite number of tanks in series, formed by partitioning a long cylindrical shell. If agitation is provided in each compartment of the shell, the situation will be exactly the same as that considered in the series-tank diagram, with random flow in each tank in addition to general flow through the system. Now consider the number of tanks to be increased so that the axial depth of each decreases, without changing the volume of the cylinder. As this process is continued, the opportunity for random flow along the axis of the tank

* These charts are based on work of the authors,[2,3] which carried further the studies of retention time in various numbers of tanks in series initiated by Ham and Coe[1]. The results were plotted for easy use and the method was extended to consider the degrees of completion of reactions of various kinetic orders that could be achieved in various numbers of tanks. More recently, various aspects of these problems have been examined by other writers.[4,5,6,7,8] Brothman,[6] for example, assumed an agitated tank in which completely "channelized" flow is recirculated at a known rate, rather than the instantaneous mixing assumed by Ham and Coe and the writers. Damkoehler[8] and later Hurlburt[8] assumed "streamlined" flow with any mixing taking place only normal to the flow axis, and extended the study of continuous reaction systems to include also consideration of diffusion, heat and fluid flow.

† The order of a reaction depends on the number of reacting molecules involved. For example A→C+D is first order; 2A→C+D or A+B→C+D is second order; while 2A+B→C+D is third order. Whether a reaction actually follows its theoretical order depends on the relative initial concentrations of reactants (where one is in great excess a theoretical second order reaction can be treated as a first order); and on whether the reaction actually proceeds as a series of lower order reactions, as can be determined only by experiment.

** Where the kinetic order is high, i.e., second or third order, it will be found necessary to use a fairly large number of stages to even approach the efficiency and capacity of a batch system. We know of one second order reaction that is carried out industrially on a continuous basis. The generation of chlorine dioxide gas from chlorate and acid is such a reaction. It is a ticklish reaction to handle, and the rate of evolution of gas must be kept constant in order to maintain a certain percentage by volume in the air stream used to carry the gas through the reaction system and the absorption system following it. If the concentration is too low the absorber won't absorb. If too high, the plant is likely to blow up. Obviously a batch generator is out of the question. To carry out this second order reaction with a reasonable recovery, as many as 10 stages is required. Incidentally, the laboratory experimental work on this process was carried out batchwise, and yet the calculated performance of the continuous multi-stage system, thousands of times as large as the experimental set-up, was verified in practice with a high degree of accuracy.

will decrease until, with an infinite number of compartments, the only random flow possible will be that normal to the axis. Hence, all portions of the general flow through the cylinder must advance at the same rate.††

So far this article has presented the negative view of continuous processing from a time-volume efficiency standpoint, neglecting several factors which may make it more efficient than batch processing in individual cases. Usually the most important of these factors is the time that continuous processes save in having no filling, heating up, cooling down, emptying and other unproductive periods, which lengthen the overall batch cycle. This time saving frequently offsets or more than offsets the time-volume efficiency of the batch process, enabling smaller continuous equipment to be used because it is productive all of the time, instead of only part of the time as in batch operation. Sometimes, also, it is easier with a continuous than with a batch process to change the processing conditions in a favorable direction, such as by using higher or lower temperature or pressure, or better agitation. Improvements of this kind in the process environment can, however, be credited to continuous processing only if they are not equally applicable to batch processes for the same purpose.‡

Sometimes continuous processes permit better control, although there are other cases favoring batch processing, where extreme nicety of control is needed, for example, in unbuffered neutralization reactions requiring a final accurate pH to be attained. Continuous processing usually means a lesser labor cost, but this advantage may be offset in other ways, such as higher capital investment. Sometimes the product of a continuous process is better than that of a batch process, owing to its greater uniformity. Even here, however, the less uniform batch product will occasionally be preferable. In fact, where the main reaction is accompanied by side reactions, the different exposures of various portions of the flow in a continuous system of a few tanks may actually result in emphasizing the side reactions and lowering the yield or quality of the product.‡‡

These are only a few of the numerous considerations pro and con batch and continuous processing, many of which are considered in later articles. To recapitulate some of the points discussed here:

Continuous processing usually requires a greater equipment investment owing to its time-volume inefficiency compared with batch, its usual need for equally great storage between steps, and its heavier investment in control instruments, and spare equipment such as pumps and compressors. It is usually essential to use continuous processing for vapor phase reactions, but for other types the continuous method is better suited to processes of lower kinetic order or with rapid or reversible reactions.

Batch processes, on the other hand, are usually better suited for the higher reaction orders; for non-reversible reactions; for cases where an extreme completion of the reaction is needed; and sometimes where side reactions are better distributed in batch operation.

To conclude this brief introduction, the fact that a noticeable trend toward the continuizing of chemical processes exists is a sign that these processes are approaching maturity, that they have gone through their trial mutations and are approaching the best method for carrying them out. The trend does not signalize inherent virtue in continuous processing, nor inherent inefficiency in batch. In any case, the changeover from batch to continuous processing is generally a costly one. It is not something to be undertaken lightly by the uninitiated.

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8. Hurlburt, *Ind. Eng. Chem.*, **36**, 1012 (1944) (interpretation of Damkoehler).

†† Carried to the extreme, this results in a "pipe line" reactor. For processing that is strictly adiabatic, and in which the fluid is either homogenous or, if heterogenous, requires mechanical agitation to maintain uniformity of composition, the flow through the pipe line reactor may be laminar. If these special conditions do not apply, the flow must be turbulent. The criterion to establish turbulent flow is, of course, the Reynolds number. This type of reactor is of rather limited application, because of the extreme length of small diameter pipe required for adequate holding time under a velocity great enough to give turbulent flow. Where the reaction involved is instantaneous, as in neutralization of acids and bases, pipe line reactors are readily applied.

Other types of "streamline," or displacement-type chemical equipment, include, for solids or heavy slurries: screw conveyors; long rotary kilns and dryers; long continuous-flow tube mills; the Swenson crystallizer. For fluids: baffled vessels, such as tubular condensers; catalytic chambers; packed towers for absorption or stripping (without recirculation of liquor); Archimedes screws, screw pumps; uniflow tower plates for bubble cap columns, decanters; classifiers; thickeners.

‡ Occasionally, operations will be found that are impossible batchwise, but quite possible continuouswise. For example, suppose we are dealing with a substance requiring fractional distillation for separation from a higher boiling impurity. Suppose, moreover, that the liquid substance cannot be boiled for any appreciable length of time without polymerizing it, although it is perfectly stable in the vapor phase. In a batch still the substance would be ruined in the pot. In a continuous still, only the high boiling impurity would reach the reboiler, while the desired substance would be vaporized rapidly in the column and removed overhead.

‡‡ Some operations are inherently more favorable when carried out batchwise. Where successive reactions are involved, as in substitutive chlorination of a hydrocarbon, the distribution of the products of the reaction will usually be different depending on whether the reaction is carried out batchwise, or continuously in a single stage. As the number of stages is increased, the end results approach each other. The choice of type of reaction system then depends on what distribution is considered preferable. In cases where over-chlorination is undesirable, the batch system gives better economy in raw material consumption and in the amount of under-chlorinated materials recycled.

HISTORICAL VIEW OF CONTINUOUS PROCESS DEVELOPMENT

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SUPPLYING chemicals in the required quality to the consuming public at a reasonable price is the task before the chemical industry. In our competitive system the concern that can work out a better process for the manufacture will generally get the larger sales because it is good business for this manufacturer to pass on at least a part of his profit by the reduction of price. Consequently he increases his sales and stabilizes his market. Largely because of the spectacular success the petroleum industry has had with continuous processing, the impression prevails that this should be the aim of most branches of our chemical manufacturing and other process industries in the furtherance of the endeavor to reduce cost of manufacture. While the petroleum industry has achieved this great success, it is also true that other branches of the chemical industry have employed continuous processing for many decades and long before the genesis of the continuous procedures in the petroleum field. An examination of what has been done in the past and how these continuous processes have developed ought to enable us to better decide the competitive position of continuous procedures.

In the development of a process almost invariably the first stages involve laboratory batch reactions. As the process is tried out in the pilot plant to ascertain the engineering factors necessary for industrial manufacture, the chemical engineer must decide whether to build his pilot plant on the batch or continuous plan. Sometimes he will try out both and will then choose that which meets his situation the better.

Frequently the initial plant processes are conducted batchwise with the change to continuous methods when the size and the continuity of demand warrant. On the other hand, there are certain procedures such as the manufacture of explosives wherein many chemical engineers consider that safer control can be secured batchwise. (Others consider continuous operation safer.—Editor.) In England during World War I, picric acid was manufactured continuously in a ceramic trough nitrator. In America, chemical engineers have preferred batch nitrations not only for picric acid but for other explosives as well.

HISTORICAL DEVELOPMENT

In studying the historical development of the chemical industry and particularly with relation to continuous processing, it may be well to divide this into the following main heads of acids, alkalis, glass, miscellaneous inorganic chemicals, miscellaneous organic chemicals, intermediates and dyes, sugar, petroleum, textiles, rubber, and soap. By this observation of the developmental stages of the different types of

procedures, some general principles can be laid down which will assist chemical engineers in choosing between batch and continuous sequences.

Before proceeding to the historical picture, it might be well to take a view of the present situation and see what the past has changed into. Probably as good a cross section as any can be obtained from the types of flow sheets given in "Chem. & Met.'s Chemical Engineering Flow Sheets."* This flow sheet book has 150 such procedures in it which classify as 50 batch; 69 continuous; and 31 batch-continuous. This view of the present picture will only pertain to large-scale manufacture for which it was found worthwhile to have a flow sheet made. There is no question about the fact that there are so many small-scale batch operations that if the entire chemical industry is classified numerically, the relative number of batch sequences will be very much higher. The batch-continuous sequences are such ones as for basic magnesium carbonate and photographic film and paper (Flow Sheets, Nos. 35 and 49)†, wherein an important stage is carried out in a continuous manner but the other procedures are conducted batchwise. Those classified as batch or continuous include those in which at least the large preponderance of the steps are conducted either batch or continuously.

HOW INDUSTRIES STAND

Acids—The tendency in the last generation has been definitely towards continuous processing for the making of acids. This has been caused by the large scale involved and by the fact that the basic unit processes and unit operations are susceptible to the exact control required by successful continuous procedure.

Probably every sulphuric acid plant, whether chamber or contact, that has been operated in this country has always been on a continuous sequence but in the early days in Europe and before the invention of the Glover and Gay-Lussac towers, the old chamber process was conducted in a batchlike manner. However, this was not true of nitric acid because up to and through the period of World War I, nitric acid was made in the United States from Chile saltpeter by heating with sulphuric acid batchwise in large cast iron vessels. The unit process involved in carrying out the reaction extended through a number of hours, during which the conditions changed considerably in the cast iron kettle both as to fluidity of reaction and temperature required so that chemical engineers at that time considered the batch procedure to be most easily carried out. However, the picture changed considerably with the making of nitric acid from ammonia by oxidation which is a very quick reaction to NO, followed by a moderately slow reaction for the conversion of the NO to HNO_3. The basic chemistry of the continuous manufacture from ammonia has been known for a long time, having largely been worked out by Wilhelm Ostwald. It was only when the price of ammonia approached 4 cents a pound that chemical engineers designed equipment to make nitric acid from these reactions in a continuous fashion. In the batch procedure, the steps vary in point of time from the raw materials to the finished nitric acid while in the continuous sequence, the conditions vary in relation to distance from raw material to product.

Practically all of the nitric acid consumed in World War II is made by this newer continuous method which is, however, based upon stainless steel for the absorbers and secondary oxidation towers (Flow Sheets, No. 40; Shreve, p. 411). The stainless steels were not available in World War I. From this we may state that one of the prerequisites for continuous manufacture is to have the materials available out of which can be constructed the equipment necessary to put the unit processes and unit operations on a continuous basis. Obviously this means to do so without unreasonable shut-downs for repairs or for other interruptions.

Alkalis—The writer would classify the making of soda ash as a continuous procedure even though it is well recognized that the carbonating towers must be cleaned every four or five days of their crust of accumulated sodium bicarbonate by having the raw brine passed through them while it is being purified. Indeed, if we accept such a very occasional interruption, the ammonia soda or the Solvay process for making soda ash is an outstanding example of the historical development of continuous manufacture. In the early days and at present in one or two existing plants, the batch calciner is still employed for the change of sodium bicarbonate to soda ash but most of the large plants now employ continuous calciners (Flow Sheets, No. 61; Shreve, p. 277 ff), consisting of a rotating steel cylinder 60 ft. long by 8 or 9 ft. in diameter. This instance illustrates how continuous procedures have been developed. Probably nearly all of them started out batchwise but as the chemistry and the engineering were worked out and as new equipment became available, the tendency has been to make these procedures more strictly continuous, provided that the production was sufficiently large and the complications were not too severe.

It is, however, only recently that caustic soda from soda ash has been made as a continuous sequence since all the early plants were based upon the batch system. With the application in the last 10 or 15 years of the Dorr continuous equipment, particularly for the reactions and for the separation of solids from liquids, the continuous manufacture of caustic soda has received wide application (Flow Sheets, No. 17; Shreve, p. 283).

Glass—It was only about 35 years ago that glass and glass articles were manufactured by hand and in batches. In the interim, the glass industry has been completely transformed until now glass windows, glass bottles and almost all other glass articles are made in a continuous almost automatic manner with decrease in cost and increase in uniformity and quality (Flow Sheets, No. 90; Shreve, pp. 218-234).

Miscellaneous Inorganic Chemicals—While most of the miscellaneous inorganic chemicals are made by the batch system, there are a few that are manufactured in a continuous manner. As we look backward, it is observed that this change took place when production arose to the economical point to consume a larger volume and when the equipment became available. Such examples are the continuous procedures for making ammonium or trisodium phosphate (Flow Sheets, Nos. 73, 86; Shreve, pp. 347-349), as well as sodium phosphate from phosphoric acid. Here not only are the chemical reactions of the unit process of neutralization carried out continuously but also the unit operations of crystallization, drying, etc., are so conducted. This change from batch procedure arose probably about 15 years ago.

Sodium chloride—or common salt—is a chemical for which there is a large demand. Certain batch procedures are still practiced as for instance in the employment of the open steam heated grainers. The salt that has been made for the last 40 or 50 years in Michigan by the vacuum concentration and crystallization of the salt brine pumped out of the underground salt beds is carried forward in a continuous manner using triple- or quadruple-effect evaporation (Flow Sheets, No. 59; Shreve, p. 260) with continuous removal of the crystallized salt as the process feature.

When American chemical engineers started the development of potassium chloride from the complex brine at Searles Lake, San Bernadino County, Calif., they faced the stiff competition of the well developed German processes. Following extensive pilot plant developments, these engineers chose the same continuous multiple-effect evaporation for the potassium chloride, borax and salt from Searles Lake that had been previously worked out as economical for common salt. The phase rule conditions were exceedingly complex and took years to commercialize (Flow Sheets, No. 57; Shreve, pp. 243-248). While there are a number of batch procedures still used by the American Potash & Chemical Corp. at this plant, it is interesting to note that as the years have gone by there has been an increase in the amount of continuous processing.

MOST INORGANICS BATCH

The larger number of inorganic chemicals made in this country still use the batch system, largely because the volume of production does not warrant the expense of changing to continuous processing.

Miscellaneous Organic Chemicals—These are made almost always by the batch procedure because of the great complexity of the chemical reactions or because of the lower volume of production. However, there are certain outstanding exceptions to this usual practice. Among these we may select the making of phenol from chlorobenzene by the Dow Chemical Co., using high pressure reaction of chlorobenzene (Flow Sheets, No. 44; Shreve, p. 856) with caustic soda solution.

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* Fourth edition, revised and enlarged by T. R. Olive with R. Norris Shreve, *Chem. & Met.*, New York, Dec. 1944. Further text references to this book in this article given as "Flow Sheets, No. xx."

† See also Shreve, "Chemical Process Industries," McGraw-Hill Book Co., Inc., New York, Apr. 1945, pp. 214, 473. Further references to this book in this article given as "Shreve, pp. xx."

Another important organic chemical that has been made in a continuous manner for nearly a century is ethyl ether. The procedure was worked out by Dr. E. R. Squibb and published many years ago in his "Ephemeris" (Squibb, E. R. *et al.* Absolute Ether, *Ephemeris*, **2**, p. 586, 1884; see also Squibb, *Amer. J. Pharmacy*, **28**, p. 385, 1856). The essential reaction involves the continuous addition of alcohol to some sulphuric acid in a reaction vessel, topped by a washing and a distillation unit which continuously rectifies the ether from the recovered alcohol and water.

While we boast of our splendid columns and distillation units nowadays, if one looks back over the last 50 years, one is struck by the efficiency of the early continuous columns that were employed for the rectification of volatile liquids, of which alcohol was an outstanding example.

EFFECT OF VARIETY

Intermediates and Dyes—Almost without exception the batch procedure is used for these chemicals because of the great variety that must be made frequently, but successively, in the same equipment. The basic chemical reactions involved require careful control and it has not been economical for the chemical engineer to go to the expense required for the standardization and instrumentation needed for continuous manufacture. It is well known that batches of dyes vary from time to time and the writer has often thought that in the case of a few large production dyes, more uniformity of quality might be secured by making these in a continuous sequence even though done on a smaller scale than would be usual. So far as has been published, however, this has not been commercialized for complete processes although a number of steps involving unit operations are conducted in a continuous manner, such as filtration on Oliver filters or distillation in continuous columns.

Sugar—This industry is characterized by the fact that practically all the steps are unit operations. An exception is in the hydrolysis of starch to sugars and in the purification of sucrose from beets. The sugar industry is an old one and many of the unit operations have been streamlined to an almost continuous sequence as for instance in crushing, filtration, and evaporation for cane sugar but many steps are still conducted batchwise in order to secure the desired control. Yet these batches are so multiplied that they may be integrated into an almost continuous stream, i.e., a batch-continuous process. An example of such an integrated step is the use of small minglers at the start of the refining of cane sugar and the employment of "strike" pans for taking care of the variable and final crystallization of sucrose (Flow Sheets, No. 141; Shreve, p. 64-629).

Petroleum—All recognize that the petroleum industry by its development over the last 40 or 50 years from batch procedures to continuous ones, has presented a challenge for other industries to emulate. It is a long distance from the early batch cracking still employed by Burton to the modern continuous cracking still. However, this transition, which has historically taken place in the last generation, has been one of the reasons why we have been able to fight World War II with plenty of gasoline for the Army and Navy. Another phase of petroleum's contribution to continuous manufacturing has been the demonstration of the economic feasibility of carrying out of procedures by continuously pumping petroleum fractions through various arrangements of pipes and bubble-cap columns, wherein a desired unit process, for instance pyrolysis, or a unit operation, for example, distillation, are all carried through continuously.

Synthetic Textiles—When we first started to manufacture synthetic textiles, shortly before World War I, the best conditions for a salable product were not fully worked out. Therefore, the first plants were conducted in a batchwise manner with naturally some continuous operations. Using batches, particularly for the chemical reactions, enabled the conditions to be easily changed from time to time until, as a result, the synthetic fibers were greatly improved in quality with the passing of time and the increase in the experience of the chemical engineers. Historically, the same picture is beginning to appear as is true in other industries because those responsible for management of the manufacture of such fibers are beginning to think in the direction of continuity. A few years ago a plant was installed (Olive, *Chem. & Met.*, **45**, p. 668, 1938; also *ibid.*, **49**, No. 10, p. 116, 1942, for pictured flow sheet) wherein many of the essential steps in the manufacture of viscose continuous filaments are carried out on a complex machine but in a continuous manner. We look to see an enlargement of this type of filament manufacture.

SYNTHETIC RUBBER TREND

Rubber—While synthetic rubber has been made partly batchwise and partly continuously (Flow Sheets, No. 133; Shreve, p. 790), steps are now being taken to put this important chemical product on a continuous sequence in conformance with present increasing knowledge and large scale production.

Soap—This industry is an old one and has conducted many of its unit operations in a continuous manner. Recently much

(*Continued on page 117*)

October 1942 did not mark the end of an era in the petroleum industry, for the era had already ended. The date did mark, however, the occasion when these historic Burton stills in the Whiting, Indiana, plant of Standard Oil Co. of Indiana joined the wartime scrap drive; extremely marked is the contrast with the modern fluid "cat craker" at Standard's Wood River Illinois, plant

ECONOMIC COMPARISON OF BATCH AND CONTINUOUS PROCESSING

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A CONTINUOUS process, for the purpose of this discussion, is considered to be a sequence of two or more unit chemical processes or unit operations so operated as to utilize continuous and uniform flow of proportioned entering components, or reactants, into the system and a continuous and uniform flow of products out of the system, such an operation to function for extended periods of time, such as months.

Economics is considered to mean that a continuous process must justify itself by a profitable return on the investment of capital made to put it into commercial operation. It is in this respect that one may be required to choose between a continuous or a batch-wise process for manufacturing the same product, or, in the case of a new product, to consider both methods of attack on the basis of what has been done commercially in the manufacture of similar or related products.

The economics of continuous processing should be considered in the light of unprejudiced thought and supported by careful study and elucidation of the applicable technology—all with respect to profitable return on invested capital. Some economists, for purposes of popular appeal, have propounded the advantages of continuous processing with resort to facts, figures and arguments unsupported by experience. Competent technologists also have sometimes leaned, unintentionally, to a favorable economic viewpoint influenced by association or interest. An effort is made to avoid any prejudiced points of view.

Certain well known chemical products appear to have lent themselves naturally to continuous processing, some of which are given as follows: Methanol, from carbon monoxide and hydrogen; ammonia, from hydrogen and nitrogen; phthalic anhydride by direct air oxidation of naphthalene or ortho xylene; nitric acid, by direct air oxidation of ammonia; sulphuric acid, by direct air oxidation of sulphur dioxide; hydrochloric acid and salt cake, by way of salt and sulphuric acid; acetic acid, by direct air oxidation of acetaldehyde; acetic anhydride, from acetic acid and ketene; phosphoric acid, by direct air oxidation of elemental phosphorus; formaldehyde, by direct air oxidation of methanol; and a host of others. It is difficult to visualize these products as being processed batch-wise.

On the other hand certain other well known chemical products appear to have naturally classified themselves into batch-wise processes, among which are the following: Viscose manufacture; synthetic resins; dyestuffs; dry colors; insecticides; pharmaceuticals; paints; perfumes; and others. It is difficult to visualize these products as manufactured by a continuous process.

In the case of the batch-wise processes above listed one may detect the following conditions which are probably those of limitation and which prevent them from becoming adapted to continuous processing: (1) Necessity for aging, (2) effects of infinite dilution, (3) seasonal nature of the product, (4) peculiarities of control, (5) small output of one kind or type, and (6) reaction order.

A general comparison discloses large volume of output of single products for the continuous processes listed and, by comparison, small volume output for the products listed under batch-wise processes. Further, since the writer is unable to recall a large scale example of a vapor phase reaction or process, as operated commercially in batch-wise operation, he hazards the statement that such processes may, by their nature, fall into the continuous class.

The complexity, and involved nature of the factors entering into continuous processes is such that no specific set of rules can be made to apply as related to the economic phase. Each particular case must be studied in the light of what has been accomplished by those who have had experience in operating such processes. Often a proposed continuous process can be feasible technically but unsound economically, in which case, it is doomed to discard, at least until a change in economic structure brings about reconsideration.

Economics may be considered more an art than a science in spite of the usual definition; it forms the basis of a social science which deals with problems involving human reactions and temperments, which variables will yield many different solutions to the same problem. Here the problems are not subject to experiment but, rather, to observation and interpretation by individuals, and solutions arrived at by mutual agreement. Further, that which is considered good economics by one organization may be bad economics for another depending on many different factors.

HISTORICAL

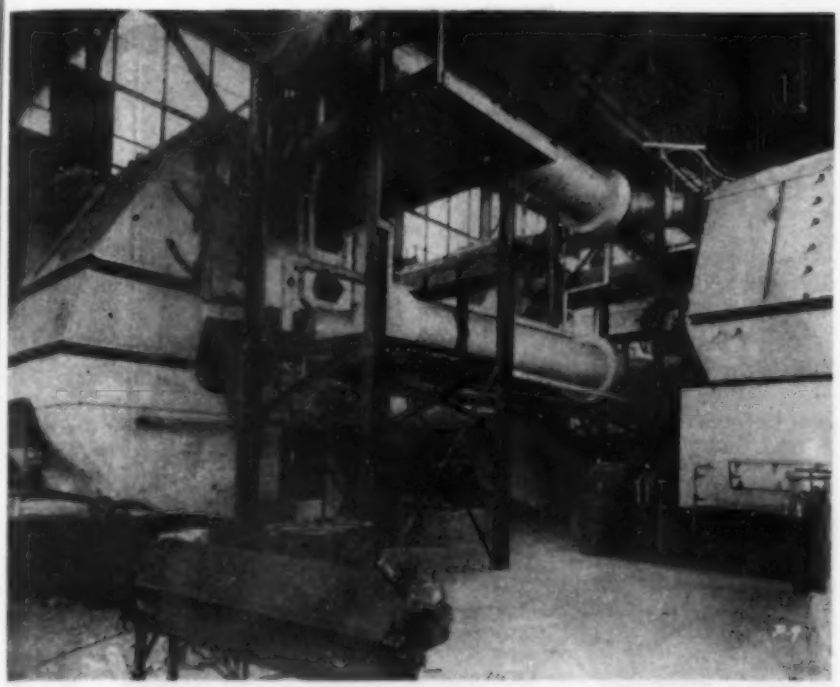
A brief review of the historical development of a major chemical industry, coal tar distillation, may bring out some of the salient points regarding the economics of continuous processing.

Prior to World War I the commercial operations in this country consisted of batch-wise distillation of raw tar for separation into light oil, carbolic oil, creosote oil, sometimes anthracene oil and a pitch residue. Many isolated plants were located over the eastern part of the country from which pitch residues and creosote oil were shipped directly to the nearest market with

SOME FACTORS TO CONSIDER IN CHOOSING BETWEEN BATCH AND CONTINUOUS PROCESSES

Editor's Note—More than 100 engineers were consulted regarding the scope of this *Chem. & Met.* report and many of them made suggestions concerning the economic factors to consider in determining whether a process should be batch, continuous, or some combination of these. The list below, much condensed, covers the main sorts of topics that were mentioned. Not all, of course, apply to any one process, product, or company. While many of them are discussed in Mr. Crawford's article, this compilation should emphasize their importance and serve as a check list for future reference.

- **Volume of market**
- **Stability of market**
- **Product acceptance**
- **Seasonal nature of market**
- **Plant location with respect to market**
- **Seasonal character of raw material supply**
- **Plant location with respect to raw material supply**
- **Financial strength of company**
- **Size of plant**
- **Cost of research and development**
- **Trends in taxation**
- **Trends in legislation affecting patents, labor, and company size**
- **Personnel quality and availability**
- **Wage level**
- **Union attitude and activity**
- **Attitude toward overtime and Sunday work**
- **Unit value of product**
- **Nature and/or form of product**
- **Unit operations and processes involved**
- **Comparative quality by batch or continuous method**
- **Unit value of raw material**
- **Uniformity of raw material**
- **Sensitivity of process**
- **Ease of control**
- **Cost and availability of suitable automatic instruments**
- **Rate and order of reaction**
- **Aging or holding time requirements**
- **Safety**
- **Ability to test or check product quality in time available during process**
- **Spoilage due to breakdowns**
- **Storage requirements**
- **Quantity of material in process**
- **Physical limitations of plant size**
- **Cost of equipment**
- **Number of products to be produced in same equipment**
- **Volume flexibility of equipment**
- **Frequency and ease of cleaning**
- **Ease and cost of starting or stopping process**
- **Need for standby equipment**
- **Ease and cost of change over from batch to continuous**
- **Availability of suitable construction materials**
- **Prospects for obsolescence**
- **Maintenance and replacement**



Equipment for continuous chlorination of benzene by air and HCl

carbolic, light oil, and anthracene oil being shipped to a central refining plant located on the eastern seaboard where batch fractionation and other unit operations were conducted for the recovery of naphthas, solvent oils, phenol, cresols, naphthalene, anthracene, etc. The economics of the industry, then young, was such that it was less costly (more profitable) to have a large number of small batch process plants located at, or near, the source of tar and certain markets than to have a smaller number of large units located to receive tar from more remote distances. It became evident at the start of the war, that a continuous process might have advantages, and it is believed that an experimental continuous tar still was in operation in 1914. Within a few years after the war the various batch-wise operations were discarded in favor of continuous processes strategically located and we now find few, if any, batch operations conducted in the industry. The reasons for this change were purely those of economics in that it was more economical from an over-all cost and profit standpoint to adopt continuous processing.

It is known that continuous coal tar processing in England and Germany was commercial practice many years before being introduced in this country. This was for economic reasons peculiar to those countries. The petroleum industry, also, can be traced in similar fashion to arrive at the same conclusion.

COMMERCIAL DEVELOPMENT

It is noteworthy that war necessity was probably the main contributing factor for these basic process changes. Further, it is already known that economic improvement of a similar nature will result from the experience of the present war.

To cite a more recent case, consider for example, the operations of the synthetic resin industry. In the early days of this industry the market for products was small and the future of the plastics industry was not yet established. Individual orders for resins and similar compounds were small and, since standards had not yet been established, each customer wanted something slightly different than the product desired by any other concern.

A new organization entering the field, with the then already fairly well established competition, had the above facts to face together with limited funds, relatively large expenses for research, process development, product development, and market development. A quick glance at these conditions indicates, at once, that a batch process, with a few well chosen pieces of multi-purpose equipment, would best fulfill the requirements of minimum plant investment, minimum cleaning between batches of different materials, and a minimum of obsolescence, as products and processes changed with continued research. At the same time these few pieces of equipment coupled with an adequate labor force, could fill any expected order, and operating expenses were held at a low figure by allowing the labor force to fluctuate in size.

As the industry grew, standards and general purpose materials were developed. Single orders became larger and, in general, became more frequent. Plant runs on a single type of material became longer, and proper scheduling minimized the cleaning necessary between types of material. The labor force necessary to handle the product and the buildings necessary to house the multiplicity of batch machinery became excessive.

With the future of the industry now assured, with markets well established and reasonably secure, with long runs on a single type of material a reality, with customer demands necessitating plant expansion and with sufficient capital available for the expansion and any justifiable mechanization, it is readily seen that this expansion should include as much "continuization" as possible in order to cut down on the additional labor requirements and housing. The older batch process should be retained, however, in part at least, to handle specialty products, small orders of special purpose materials, and semi-plant production of new products. Thus, we see that even in an industry as well established as the synthetic resin industry it will always be advisable to maintain some batch operations.

Since most of the chemical unit processes and operations have been operated commercially in continuous fashion it naturally follows that their combination can be fit together into a sequence making up a continuous process as a whole.

SYNTHETIC PHENOL

Such a combination is well illustrated by a continuous process for the synthesis of phenol commercially developed in this country by Durez Plastics & Chemicals, Inc., after study of a small pilot plant operation in Germany (discussed fully in *Chem. & Met.*, Nov. 1940, pp. 770-5).

This involves the unit processes of halogenation and hydrolysis and the unit operations of fractional distillation, absorption (vapor), extraction (liquids), mixing (gas and liquid), evaporation, heat exchange (gas and liquid) and decantation, all in continuous fashion.

As originally conceived in 1928, this process involved nothing more than the liquid phase chlorination of benzene to chlorobenzene and the subsequent alkaline hydrolysis, under pressure, of the chlorobenzene to phenol—both well known batch operated reactions. As development proceeded, the process soon evolved into continuous chlorination and hydrolysis, and through successive improvements, by 1937, into a continuous vapor phase process, wherein benzene vapor was catalytically chlorinated to chlorobenzene by the chlorine oxidized from HCl with air, in a clever modification of the old Deacon chlorine process. To accomplish this, a continuous flow of benzene vapor from a still is superheated in steel tubes, and mixed with a controlled flow of HCl and water. It is then vaporized from an acid still with atmospheric air, the temperature of the mixture being controlled at about 210 deg. C. This flow is then brought in contact with a catalyst whereby the following generic reaction occurs:

$$C_6H_6 + 1/2\ O_2 + HCl = C_6H_5Cl + H_2O \quad (1)$$

Since equilibrium does not take place in the practical operation of this reaction, an excess of benzene appears on the right of the above equation and, since condensation must be effected, the products of the reaction are subjected to continuous fractional condensation by being required to evaporate a reflux of water supplied to the column, thus supplying a two phase mitture leaving the bottom and consisting of an upper, organic layer of crude chlorobenzene in solution in the excess benzene and a lower water layer. These are continuously decanted and the pure chlorobenzene recovered by continuous fractional distillation, the benzene overhead vapor from the still supplying that component for chlorination.

To accomplish hydrolysis the chlorobenzene produced by Reaction (1) is continuously fed, together with the water portion decanted from the products of the chlorination step, vaporized, superheated and brought into contact with an hydrolysis catalyst whereby the following generic reaction takes place:

$$C_6H_5Cl + H_2O = C_6H_5OH + HCl \quad (2)$$

It is pertinent to note that here HCl is split off in amount to satisfy Reaction (1), therefore, by continuous absorption with a hot water reflux in an acid brick lined, packed column, the HCl is recovered in the form of a strong aqueous solution and continuously evaporated by steam heated tantalum coils to supply the HCl component of Reaction (1). Total equilibrium is not practical in the operation of this reaction and there appears on the right hand side of the equation the unconverted C_6H_5Cl and H_2O in addition to the C_6H_5OH after washing out the HCl. The conditions of the operation are such that the vapors leaving the HCl absorption column are azeotropic in nature and the C_6H_5OH is absorbed continuously in a column by a reflux of water at 90 deg. C. Under these conditions the phenol is recovered as a water solution which leaves the bottom of the column and, because any temperature within the column is maintained above the azeotropic boiling point of C_6H_5Cl-H_2O, this component leaves the top of the column in the vapor state to be recirculated to the hydrolysis catalyst chambers by means of a fan.

The phenol-water solution leaving the bottom of the phenol absorption column then is pumped to a continuous, countercurrent, extraction column wherein the phenol is extracted by liquid benzene entered at the bottom. The phenol benzene extract leaving the top of this extraction column flows to a continuous still which separates crude phenol as bottoms and benzene vapor as overhead, which latter provides benzene for chlorination by Reaction (1). For ordinary purposes of resin manufacture the crude phenol is suitable, but for purposes where pure, water white phenol is required, a continuous vacuum still column is provided to produce U.S.P. phenol.

This process has justified itself on an economic basis after five years of operation for the reason that it produces phenol at a price below that which a corresponding grade can be purchased. Greatly reduced labor costs contributed strongly to the economy in this instance.

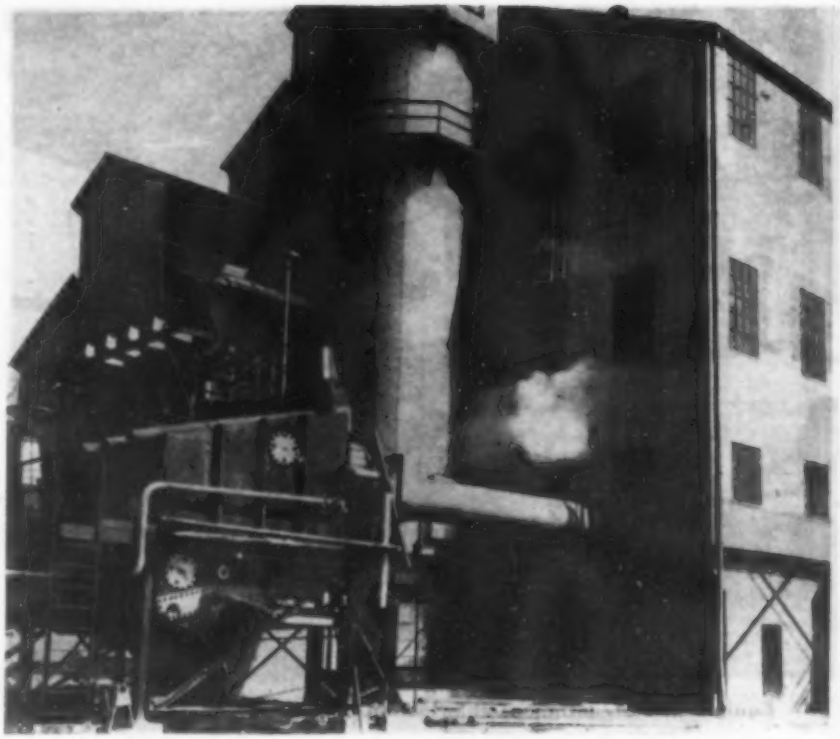
A recent example that comes to our attention, of economy resulting from the development of a continuous process from an initial batch-wise process by means of small changes and additions, will illustrate other important factors to be considered.

Initially the process consisted of an agitated, jacketed kettle into which 16,000 lb. of a monomer was charged, catalyzed and reacted to 20 percent solids. When this point was reached the unreacted monomer was distilled off and condensed for reuse. The remaining resin was then dumped, batch dried and sent to storage for later batch blending and the kettle had to be thoroughly cleaned before the next charge. By this process the average production rate was 49.5 lb. per hr. of finished resin.

BATCH TO CONTINUOUS

The first step made toward continuizing this process provided for the installation of a continuous dryer with continuous recovery of the unreacted monomer, dumping the kettle and drying the product. This step permitted the charge to be increased to 18,000 lb., a gain of 6 hr. per cycle, but increased the dumping time to 3½ hr. A net over-all gain of 20.8 percent, however, was attained by the average production rate of 59.8 lb. per hr.

Finally, the last step came by continuously feeding the reactants and continuously discharging the reaction product to the continuous dryer. This was accomplished by the addition of one tank, one pump, some piping and the necessary control instruments. By this arrangement the average production rate was increased to 92 lb. per hr. (85.8 percent over the initial batch-wise installation).



Continuous countercurrent gas washer removing phenol from vapor mixture of chlorobenzene, water, and phenol

Although man-power requirements or chemical yield did not change, the economy of the process obviously improved, in that greater output of product per unit of process labor was realized, consequently, the return on the investment was increased by the adoption of a continuous process.

SAVINGS EFFECTED

Certain general features of commercial continuous processes appear to bear specifically on economics. Conservation of heat (energy) by recovery of sensible heat from products within the process, or heat from exothermic reactions, is a very common attribute of continuous processes. Here one finds wide recourse to the use of various types of heat exchangers which conserve heat by continuous exchange between liquids, liquids and vapors, vapors and vapors, and even solids and vapors (gases). In this respect we find pertinent existing examples in the unit processes of: Hydrogenation (methanol, ammonia), oxidation (sulphuric acid, methyl chloride), halogenation (chlorobenzene, methyl chloride), hydrolysis (phenol, isopropyl alcohol), alkylation (toluene, tetraethyl lead), amination (aniline by ammonolysis) and others. Here it is noted that a single unit operation may contribute to the economy of several continuous unit processes. Those intimately familiar with the above processes would doubtless find other unit processes contributing to economy.

Conservation of space, and therefore equipment is a definite factor in that most, if not all, continuous processes occupy less space and equipment than do batch-wise processes of the same magnitude. This resolves itself, in the last analysis, to economy in the use of capital and, therefore, profit which is the determining factor in economics. To cite a specific example, hydrochloric acid and phthalic anhydride have been manufactured in large quantities by batch-wise processes but both now are continuized simply because the batch-wise method yielded a lesser return on its investment than the continuous method and, for the same output, required considerably more space and equipment.

Conservation of power (no power peaks and demand charges) is apparent in most continuous processes because the quantities of process material in motion at any moment of time are much less than those in a batch-wise process, thus power in the form of electric energy is conserved with consequent economy. Other continuous processes are also in operation making use of vapor pressure differentials to operate prime movers such as circulating fans and blowers and even turbo-generators with favorable effect on economy by producing by-product power within the process.

Conservation of labor is another well known attribute of continuous processes in that the labor dollars per unit of product produced is extremely low because comparatively few men are required to operate large scale continuous processes. The economics here is so obvious as to require no further comment.

Conservation of capital is a debatable point because sufficient information of a pertinent nature is not available with which to draw good comparisons.

It would appear, however, that even though the investment in continuous processes, for a given production, may be larger than that for a batch-wise process of the same output, the over-all profit (return) must be greater since, otherwise, there would be no incentive for capital investment, especially for those cases where duplication, or expansion, of continuous processes have been repeatedly made.

One may draw from the above discussion that several factors are of paramount consideration as bearing directly upon the economics of continuous processes.

BROAD CONSIDERATIONS

Market Trends—With a new, or infant, industry or process the potential market for a product is not known and in this event it would be in keeping with the accepted principles of business to keep plant investment and risk as low as possible by using batch-wise processing. The general effect under these circumstances would be to have low fixed charges in the form of interest, taxes and depreciation but high unit processing costs as regards labor, supervision, steam, water, etc., and possibly, materials (if bought in small quantities). In this case, the higher unit costs would be absorbed, or overbalanced, by the high selling cost usually encountered in such instances.

In the case of an established industry or process, there are two possible variations with respect to a given product. The market may be saturated and prices low in which case it may not be desirable to enter the field even to supply one's own requirements much less to sell in a saturated market. The market, however, may be an expanding one, the desirable state in which other factors may weigh more heavily in favor of a continuous process. Here the opportunity exists to study carefully the possible advantages of a continuous process with the view of the lowest possible unit cost of production and with the thought in mind that the product may surely be required to survive a falling market in the normal course of events.

While it may appear to be digressive here to consider company policies with respect to product prices, the matter is nevertheless pertinent as bearing upon economics that could effect a continuous process. Consider, for instance, the "threat plant," possibly erected and possibly not, but publicized in proper fashion for the sole purpose of reducing the market price of a product—nevertheless this is economics.

Variety of Products Required—Sometimes a variety of similar products is possible from the apparatus of a continuous process. Here the necessity and completeness of "clean-up" between product runs and the time length of individual runs are important because of the "down time" introduced. Long runs of production can be made in continuous processes even though down time for clean-up is introduced occasionally. Batch-wise operation is very often given the effect of continuous operation where designed to accommodate short runs of different materials and wherein the first and, in order, successive, steps of a sequence of operations can be shut down, cleaned, and put into operation on the next product run even though the running product has not left the final step of the sequence.

Financial Status of Company—Since a continuous process, especially of the higher orders may involve a greater capital expenditure than a batch-wise process for the same output and is not usually susceptible to expansion unit-wise in the same manner as a batch process, it is usually the procedure to design certain critical portions larger than necessary with a view to the unforseeable future. Thus, the company having plenty of capital is better able to finance a continuous process than a small company having limited capital.

Personnel—Labor status is an all important consideration in view of our present sociological system where, under unionization, the trend is toward higher wages, minimum annual pay, less work and shorter hours; where government tends to encourage this trend and, in addition, seems to have an adverse attitude against patent protection. It might appear that these conditions are working against elaborate continuous process developments but it is believed, however, that these are actually favorable to continuous processes for a number of reasons.

LABOR IMPORTANT

In batch-wise processes the batches must be started on a predetermined schedule and throughout the "run" conditions are constantly changing. When a new operator comes on duty, at shift change, it is necessary for him to review the log of each piece of equipment under his control in order to know the exact condition of each batch. It is necessary then to maintain a very complete log, or running record, of each batch and very complete supervision, in order that the possibility of off-grade or spoiled batches can be minimized. As the working time of shift operators become shorter the number of chances for errors are, of course, increased in direct proportion. Too often it is found that if the starting time of a batch falls near the end of a shift, the operator will invariably delay charging. His relief, then, has the task of starting off the batch resulting in unnecessary down-time.

With a properly designed continuous process, on the other hand, process conditions at any point are substantially constant from time to time, day to day and even month to month, thus eliminating the above potential down-time. The chance of an upset condition in the continuity of operations occurring just at shift change is quite remote.

In batch-wise operation the number of operators required is generally greater. This is due, in part, to the necessity of handling material in process and, in part, to the marked tendency of unions to limit the number of operations under the control of one man. In the continuous type of processing there is no such handling and actual control is had with instruments which are located at a central control point and the operator's duty becomes mostly that of making sure that the instruments are functioning in the proper manner, making scheduled valve changes, and the like, where automatic timing devices are not provided.

The above features of a batch-wise operation can be, and often are, minimized by complete instrumentation, including time-cycle control. Complete instrumentation should be given most serious consideration where a batch-wise process must be used for technological reasons, but, it should be noted that frequently the additional cost for complete instrumentation may overbalance the saving on overall equipment cost made possible by batch-wise processing over continuous processing, where either method is possible.

CAPITAL INVESTMENT

The relative costs of capital and labor since 1932 and the enactment of various regulations concerning labor and business have forced manufacturers to the expedient of adopting all manner of means to reduce the number of employees, such as by the use of labor saving devices. This situation seems to react favorably toward the wider use of continuous processes since they usually require fewer operators.

In 1933 the chemical industry in this country had an average investment in physical assets approximating $7,000 per employee. In 1942 this ratio had risen to about $10,000 per employee, unit costs had decreased as did selling prices—better economy in other words. Specifically, as regards known data relating to the commercially successful continuous processes, this ratio in 1942 appears to be about $30,000 per employee—three times the general average.

From this it appears that the labor costs for continuous processes have been reduced in much greater proportion than the general average for all processes. It would seem, then, that continuous processes, in general, can bear a high plant cost on the basis of greatly reduced labor costs.

Continuous processes cannot displace all, or even most, of the existing batch-wise processes within the forseeable future, but there should be an increase in their development and application according to individual merit as they can be made to fit into the economic structure of the industry.

Continuous separation and washing of chlorobenzene from benzene

HOW CONTINUITY AFFECTS UNIT OPERATIONS AND PROCESSES

EDITORIAL STAFF

Editor's Note: *In planning this report on continuous processing more than 100 chemical engineers made suggestions regarding content and scope. Many suggestions pertaining to unit operations and unit processes were received, some being incorporated here with only this general acknowledgement, while others, more lengthy, are included as direct quotations or as short articles.*

One of the approaches to a decision whether a particular process is best handled by batch or by continuous methods, or by some combination method partaking of the characteristics of both, is to examine the unit operations and unit processes that make up the over-all process. With the assistance of many people who have offered suggestions, the editors have attempted to make such an examination. No very important conclusions of a general character were reached, but a number of significant facts were uncovered which seem worth setting down here.

A simple philosophy of chemical processing helps in the consideration of the parts that make up the process. The function of chemical process industries is to take raw materials of low use value and put them, by physical or chemical changes or by combinations of both, into forms where the use value is higher. In carrying out the general aim there are a comparatively few kinds of things that the chemical engineer can do to the material (although, there are a great number of ways in which these things can be accomplished). These kinds of things include (1) Moving the material into and out of the plant, into and out of storage, within the process and between process steps; (2) changing the state of aggregation of the material, that is, breaking it down into smaller particles, or sometimes compressing particles together or otherwise assembling them into larger aggregates; (3) mixing various materials of the same or different phases together; (4) separating materials, or different sizes of the same material, which may be associated in mechanical mixture, solution or emulsion; (5) changing the energy level of the material by heating, cooling or altering its pressure; (6) changing the phase of the material by changing its energy level; and (7) bringing about a chemical change in the material or a mixture of materials. In addition, there is another kind of thing that can be done, although not to the material itself, that is, (8) control any of the first six categories listed above. Control is specifically excluded from the seventh for a reason that will be explained.

The first six classifications of things that can be done to materials in processing operations are all physical in nature. They are the unit operations of chemical engineering. The seventh is chemical and encompasses the unit processes. Unit processes however, cannot be carried out by themselves. They are dependent upon proper choice of the unit operations which are conducted simultaneously, and upon control of the unit operations. This control must be such that the desired environment for the reaction or process will exist and will minimize undesired reactions, cause the reaction sought to proceed at the greatest practicable speed and to the greatest practicable degree of completion.

Without exception all unit operations and all unit processes can be carried out in a continuous manner, or in a batch manner, as well as in ways that are intermediate between the two extremes. Whether or not a given operation or process is batch or continuous can have two main effects only: the cost of the product may be affected, favorably or adversely, or the quality may be affected. In most cases these two effects are interrelated through the over-all return, which in the last analysis is the determining factor. That is, a poorer product can probably be sold, although for less, and may still net a higher return by reason of lower production costs; whereas a better product, although it may command a higher price, may still be less profitable on account of higher production cost. The final effect on the over-all return must in the end decide what mode of operation is best in any given case.

COMPLEX CONTINUITY

That is not to say that all processes and operations can be conducted either batchwise or continuously with equal ease. In many instances the sort of equipment needed for continuous or approximately continuous operation is far more complex than is needed for batch operation. The problems of control of this more complicated equipment generally make relatively complex instrumentation necessary, thus pyramiding the complexity and frequently adding seriously to the maintenance problem. On the other hand, the more nearly automatic operation necessary for continuous processes pays a dividend in reducing operating labor, often to the minimum needed for supervision of the instruments and for occasional manual operations. This labor minimum in turn sets up an economic balance in respect to automatic operation. Since labor cannot be completely eliminated, and for practical reasons should be kept at least partially occupied, it is generally found that there is a limit beyond which automatic operation is unprofitable. The same considerations may of course apply to batch operation which, however, is less frequently automatic.

In some operations and processes, but not all, the quality or characteristics of the product may be affected, depending on whether batch or continuous processing is employed. The overall cost may be affected in all cases. So far as quality or characteristics is concerned, the method chosen for moving materials may have an effect in increasing or lessening contamination or degradation, but no case has been found where the fact that the operation, *per se*, was batchwise, or continuous, had an effect one way or the other on quality. The same may not be true, however, with operations where the driving force that makes the operation "go" is something other than strictly mechanical, or where accomplishment of the operation depends on giving equal opportunity to every particle in a system undergoing treatment to be affected in the desired manner. Of all the seven kinds of things that can be done to materials, previously listed, only the movement of materials appears never to have an inherent effect. Cases can be found with all the others, although not with all the unit operations comprising any of the classes, where at least some effect on the product is possible as a result of the kind of operation, batch or continuous, that is chosen.

Moving Materials—Little need be said here regarding the unit operations of materials handling and fluids handling for the reason just mentioned (and because the control of materials flow is treated in Mr. Considine's article on p. 112). Materials movement is an adjunct to other classes of operations and processes so far as the plant is concerned, and its mode, batch or continuous, can be chosen depending on which is required by the operations it serves. The only instances where it is difficult to produce a continuous method of handling occur when it is necessary to introduce or remove solids or semi-solids into or from a process operated at pressures considerably above or below atmospheric. This can sometimes be accomplished continuously by means of screws, or almost continuously by rotary valving arrangements. Frequently, however, especially with higher pressure differentials, it is necessary or preferable to use alternate batch charging of two feed vessels which can alternately be put under process pressure and then discharged continuously to the process.

Many sorts of equipment for material movement produce discontinuous movement—that is, a rapid succession of batches—which conceivably can be upsetting to continuous processes. Generally it is possible to provide surge volume in such a way that discontinuities are eliminated.

In the past the problem of moving solid materials within the process itself has sometimes presented such difficulty that batch or batch-continuous processes or processes which are continuous only with respect to the fluids handled, have necessarily been used. Development of the

principle of fluidized solids in recent years has exerted an important effect in removing this limitation where parallel-flow movement of fluid and solid is possible. Countercurrent movement is readily possibly in some sorts of equipment such as rotary kilns and many types of dryer. Other mechanical moving means have been developed for other instances of countercurrent movement, of which the Thermofor kiln is a well known example.

Changing the State of Aggregation—It is uncertain whether the criterion of a true continuous operation applies strictly to any method of crushing or grinding, although in most sorts of grinding the mode is at least close to continuous. Actual batch operations are much in the minority. The best opportunity to compare batch and continuous grinding occurs in the ball mill since this type of equipment is operated both ways. The outstanding conclusion is that continuous grinding gives a different range of particle sizes, produces less over-grinding, and requires less power, all for the same reason, namely, that in batch grinding material remains in the grinding zone after it has been reduced to the desired size, and until the largest remaining particle is of desired size, while in continuous grinding material is (at least, theoretically) removed from the grinding zone as soon as sufficiently reduced. If over-grinding is an undesirable characteristic in the product (sometimes it is not, when a rangle of particle sizes is desired) then it is clear that continuous grinding is preferable from the product as well as the power cost standpoint.

MOST USED OPERATION

Mixing Materials—Materials may be mixed for a variety of purposes, such as to produce a blend, establish a suitable environment for a reaction, aid diffusion in dissolving or crystallization, or in the convection of heat. Mixing depends upon agitation, but agitation may also be used without mixing in keeping solids in suspension in fluids, in scrubbing saturated films from dissolving particles and in minimizing other stagnant films, as on heat transfer surfaces. As is pointed out elsewhere in this report, mixing is a random operation and its accomplishment depends on probability in relation to the time of mixing, the design of the equipment, and the mechanical effort put into the job. It is a characteristic of all systems involving fluids, or fluids with solids in suspension, that continuous flow through a mixing apparatus cannot give entirely uniform treatment to all portions of the flow, since some portions remain longer then others. Continuous systems incorporating mixing therefore cannot be strictly the equivalent of batch systems, although by staging, as described in other articles, the equivalence can be made as close as desired.

Mixing and agitation are such important operations that a separate article in this section (p. 112) has been devoted to them. Two other major articles deal with the general theory of flow-through systems (p. 118) and their design (p. 126).

Separating Mixed Materials—Many different principles are used in the separating of materials, including change of phase of one of the mixed materials; differential electrical or magnetic attraction; differential reaction to some form of resistance such as a screen or diaphragm, or a fluid through which the mixed material is moving; settling or floating in a liquid; and various combinations of these. The variety is so great that generalizations are impossible other than to state that all separation operations can be handled either batchwise or continuously, although in some cases either equipment complexity or difficulty in completing the operation continuously may throw the balance in favor of batch. If randomness (as in mixing) is not a factor it appears that in no case of separation is the quality adversely affected by continuous operation. On the other hand, continuity, or semicontinuity, often enables more complete separations to be made by operating countercurrent. Thus the dissolving operations such as leaching, washing and gas absorption, are generally better when countercurrent. Distillation is usually combined with rectification, often continuous, for a similar reason. Countercurrent drying and absorption are often desirable. Furthermore, some of the separations, particularly the mineral concentrations, would be difficult to handle batchwise owing to the small amount of material being acted on at any one time, so these are usually continuous.

Changing Energy Level—For several reasons heat tranfer generally favors continuous operation. With countercurrent exchange, the amount of heat transferred can be greater per unit area than in batch operations. Also, continuous operation usually offers an opportunity for employing recovered heat simultaneously with the recovery, thus making for higher overall thermal efficiency. Prof. K. W. Coons, consultant and head of the Department of Chemical Engineering at the University of Alabama, has supplied the following illuminating comment.

"Each process theoretically requires a definite amount of heat for its consummation. In continuous operation the instantaneous heat requirement is less than in equivalent batch operation because the heat is used continuously rather than only part of the time, which enables one to use smaller heat producing and heat transfer equipment. In addition, continuous operation usually permits the recovery of heat by countercurrent circulation of hot and cold fluids. (The same is possible also in multi-phase processes.)

"An important consideration in heat transfer is the fouling of transfer surfaces. Heat transfer surfaces that are shut down during inactive parts of a batch cycle are apt to build up with sludge or scale whereas in continuous operation there is much less opportunity for insoluble material to collect. Furthermore, as is well known, continuous operation greatly reduces the tendency toward concentration corrosion. Thus continuous operation extends both life and efficiency of the transfer surfaces."

Changing Phase—Phase change operations may or may not be used for separation. Generally the product quality is not affected by whether the operation is batch or continuous, unless the differences in environment produced by the two kinds of operation produce differences in the physical form of the material after the phase change. Effects are sometimes noted in crystallizations and precipitation operations. Crystals can be grown either way but there are instances where batch operation is still required, as in the sugar pan, for precise control of crystal size. Also in some instances where extremely large crystals are to be grown, it is claimed that batch crystallization is needed.

PRECIPITATION PROBLEMS

Precipitation operations are related both to the unit operations and the unit processes in that, although an insoluble material is thrown down (which is related to crystallization), the actual circumstances of the precipitation are closely connected with the conditions of the reaction. The editors requested and received comment on the batch-continuous characteristics of precipitations where particle sizes must be closely held, from George Walker of the Warner Co., Devault, Pa.:

"It is probably correct to say that most commercial pigments are obtained by precipitation from solution. Their physical and chemical characteristics are of great importance and must be closely held. Usually the controlling factors are time, temperature and concentration, and there is generally an optimum combination of these. However, batch precipitation differs inherently from continuous precipitation in respect to involvement of these critical factors, and the two methods can therefore be expected to give different results. To illustrate, consider a batch reaction between two solutions, *A* and *B*, which are assumed to mix instantaneously, with precipitation at the theoretical rate of reaction. Solution *A* is present in the reaction vessel and the other, *B*, is then introduced at some practical flow rate. If precipitation begins immediately when the addition of *B* is commenced, and ends shortly after the addition is completed, then the conditions will have varied continuously from 100 percent *A* and zero percent residual solution *C*, to zero percent *A* and 100 percent *C*, thus imparting a whole range of properties to the product, reflecting the range in concentration.

"However, making the same simplifying assumptions regarding continuous precipitation, with *A* and *B* entering the reaction vessel concurrently and in final proportions, remaining for the needed reaction time and leaving with the precipitate in suspension in solution *C*, it is clear that all particles will have received similar treatment, rather than varying treatment with respect to the time and concentration, and that greater uniformity can be expected in product properties.

"Perhaps, in a given instance, the greater uniformity may be desirable from a product use standpoint, but again it may not. The particular case must decide, but in any event it is reasonable to infer that the product will differ by the two methods and that the difference may be important in respect to commercial quality.

"It is also possible to detect differences in some cases, depending upon the particular method of continuous precipitation used. For example, a pigment grade of

calcium carbonate had been produced batchwise by carbonating milk of lime in an efficient design of gas-liquid mixer. Two such mixers were connected in series for continuous production and it was found that the precipitate for the first 2 hours corresponded closely to the batch product, but then began to change progressively until final stabilization at a different but constant quality occurred after 16 hours. The difference probably involved some degree of self-seeding toward specific crystal growth, and it is possible that the difficulty could have been eliminated if a pipe-line type reactor rather than a mixing type had been used.

"Another instance gave the reverse result. An attempt was made to duplicate a satisfactory batch-produced titanium dioxide, using a pipe-line type 'hydrolyzer.' Apparently control of time and temperature was suitable but the finished pigment properties were not what was desired and a long period of experiment indicated finally that the solution might lie in some method of 'return seeding.'"

Unit Processes—From time to time practically all unit processes have been demonstrated on a continuous basis although most of them, aside from vapor phase reactions and some solid reactions, are generally batch today. Many present trends toward continuous processing are in the field of reactions. On this important subject we present two articles to conclude this section, Prof. Larian's general article (p. 114), and Mr. Yeager's article (p. 113), which describes a particularly interesting example of a successful application of the pipe-line type of reactor applied to a liquid phase operation.

PROBLEMS IN DISSOLVING, REACTION AND MIXING

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As the technology of agitation is advanced through the study of performance characteristics of impellers and other basic research, it becomes possible to simplify the general definition of this unit operation. It may be thought of as a form of liquid transport within a closed vessel producing a physical change.

From the chemical standpoint, these physical changes are used to produce a desired environment for chemical reaction as well as several other simple physical results which, for convenient simplification, can be divided into groups as in the table. It is obvious that chemical reaction may occur as the result of one or more of these physical changes although chemical reaction frequently does not occur in mixing operations.

If mixing is thought of as merely producing physical change, it is obvious that it can be applied successfully to either batch or continuous flow-through operations. Difficult problems do not occur directly in connection with the application of mixers to continuous flow-through processes. Difficulties ordinarily considered in

Functions of Agitation

Blending miscible liquids	Simple mixing of soluble liquids as in reducing concentration
Mixing immiscible liquids	Washing of liquids, extraction, contacting, caustic treating, emulsions
Crystal size control	Precipitation and evaporation systems
Gas absorption and dispersion	Hydrogenation, aeration, gas scrubbing, chlorination, gas washing
Suspension of solids	Slurries, slaking lime, suspension of: filter aids, activitated carbon, fullers earth, crystals while dissolving
Heat transfer	Stills, evaporators, reactor vessels, heating, cooling

connection with flow-through agitation occur in devising accurate metering and proportioning devices. Once this has been achieved, the problem of agitation is a simple one.

In designing agitation for flow-through devices, the following factors must receive consideration:

Time Factor—Very few reactions and physical changes produced by agitation take place instantaneously. Therefore, the mixing chamber or vessel must provide a suitable retention period to insure that the chemical reaction or physical change be carried to completion before the effluent issues from the vessel. Under certain conditions of chemical reaction or physical change will be carried to pendent, or nearly so, of the amount of energy introduced into the system by the agitating device. However, in the case of many physical changes, such as simple blending of miscible liquids, the retention time or volume of the mixing vessel may be reduced if the agitation is increased.

Short Circuiting—A common difficulty in applying agitation to flow-through systems is the problem of short circuiting or the passing of unreacted or unchanged components directly through the vessel without being retained for the necessary retention time. The percentage of material being short circuited can be accurately predicted and controlled by simple means by adjusting the volume or number of vessels in series. It is also possible to recycle material to insure complete retention where a battery of vessels is used. Recycling in the case of a single vessel is not effective except for the additional volume of inventory which the piping and pump system provides.

Counterflow Processes—It is not to be inferred, however, that continuous agitation will provide the dynamic conditions which can be provided by counterflow processes, as in bubble towers, due to the fact that a single-stage equilibrium is all that can be reached in batch or single-vessel flow-through systems. Countercurrent design with continuous mechanical agitation requires extremely complicated set ups according to present knowledge.

Pilot Plant—Pilot plant design and scaling up from pilot plant to commercial operations is considerably more difficult with continuous flow-through operations than with batch. While it is possible to scale up any batch operation with usable accuracy, it is not always possible to apply batch data to design of flow-through equipment where chemical reactions are involved. Provision must be made in the commercial apparatus, therefore, for variation in the degree of agitation, so that factors not apparent in the batch operation can be met.

Power Comparisons—Considered solely from an energy balance, there should be no difference in the total amount of energy required to blend a large batch and the energy required to blend the small volume on a continuous flow-through basis. The large batch will of course require a relatively large mixer, operated for a relatively short time, while the flow-through operation will usually require a smaller mixer which operates continuously.

If the rate of flow and retention time are properly adjusted, the total amount of power consumed will be approximately the same. If, however, a small retention time is required, the power input for the continuous operation may greatly exceed that required for the batch. Retention time and power may be varied, therefore, to maintain the power within economical limits.

The small capacity pipe-line type of agitator is considered as suitable only for simple blending operations where the materials are very miscible and where sufficient pressure drop exists to contribute to the blending. However, it has been found that even in such simple applications as the flash mixing of chemicals in water and sewage treating, a mixing chamber providing 0.5-3 min. retention time is essential for best results. The merit of this practice is well borne out in more difficult applications, such as catalyst contacting and in the caustic treating and doctor treating of hydrocarbons.

Gas contacting and absorption can of course be included in the discussion of continuous mixing although in many cases the gas phase only is on a flow-through basis, the liquid being retained in the vessel.

The only common application which offers serious difficulties is the continuous dissolving of solids of low dissolving rate, or large particle size, which require prolonged retention. It will be seen that undissolved solids can be carried into the effluent unless screened out.

CONTROL OF MATERIAL FEED RATE

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Continuous flow of materials is a basic premise of continuous processing. For every pound of raw material introduced into a process per minute, a pound of finished product, byproduct, or waste must be removed from the process in the same time. A controlled rate of production, then, logically demands a controlled rate of feeding. In some processes, however, there are certain process conditions—critical temperatures, pressures, etc.—which are difficult to control. In these cases, it is often more practical to sacrifice an absolutely constant rate of production, adjusting the rate of feed to bring about the desired process conditions. In still other processes, one raw material may be fed at a constant rate while the feeding rate of another raw material may be adjusted to permit precise control of process conditions.

There are two principal methods of

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measuring and/or controlling the flow of materials through continuous processes, namely: (1) Volumetric, and (2) gravimetric methods. The method selected depends principally on the nature of the materials to be measured although in many cases a choice may be made of either volumetric or gravimetric means.

In general, gases and liquids are more suitably measured in volumetric equipment, such as positive displacement pumps and blowers, while solids are usually best measured in gravimetric equipment, such as continuous weigh feeders, automatic hopper scales, etc. The principal methods, of which there is a wide choice of equipment, include for liquids the following volumetric methods: (1) Positive displacement meters; (2) proportioning pumps; (3) calibrated tanks; and (4) orifice and venturi meters. Automatic tank scales may be used where gravimetric measurement is desirable. For solids, volumetric methods include: (1) Star wheels and other rotary "valve" devices; (2) apron feeders and other non-weighing conveyor feeders; (3) rotary disk feeders; (4) screws. Where greater accuracy of feed rate is needed the gravimetric methods used include: (1) Totalizing conveyor scales; (2) weigh feeders; and (3) automatic hopper scales. With exceptionally stable processes, or those where product specifications are not especially rigid, simple vibrating feeders, belts and screws may suffice, without control features other than feed period or speed variation.

Although control of feeding rates to continuous processing equipment is very important, there are other points in such processes where materials flow should be measured or controlled, including:

1. As materials are received: To fix the basic cost accounting charge against the process so that yields or operating efficiencies can be determined.
2. At the product, byproduct, or waste outlets of each major processing vessel: To check upon operating conditions used to determine yields or efficiencies of each equipment.
3. Before and after the juncture of two or more materials in a process. This often takes the form of continuous proportioning or ratioing equipment, followed by continuous checking equipment to make certain that the proportioning equipment is operating in good order.
4. Where materials are packed and packaged prior to shipping.

Items (1) and (4) may not ordinarily be considered a part of continuous processing, but it can not be denied that raw materials must be received and final products must be packed or stowed for shipment before a processing cycle can be considered complete. These facts are true of batch processes as well as continuous processes, of course, but continuity of these operations is especially significant if a process is to be considered totally continuous. It is interesting to note that continuous raw material receiving and product packaging are frequently the only continuous operations in an otherwise batch process.

A discussion of several industrial applications of continuous materials flow measurement and control will make clearer the operating advantages to be gained. It must be emphasized, that the limited number of examples given below are only generally true and not true of a total class of operations.

FIXED FEED RATE

Roasting, Drying, and Cooling—Various ores, chemical salts, plastics, calcines, sand, abrasives, etc., are fed to a directly or indirectly heated or cooled equipment at a fixed rate. In a system of this type, a product of desired uniformity can easily be obtained by adjusting the rate of heat input or removal through temperature control. Accurate temperature control is easily obtainable without adjusting the rate of feed. A constant throughput, accomplished through a constant gravimetric feed, imparts stability to the process, greatly aiding temperature control, and insures maximum production from a given equipment. It is interesting to note that the constant feed practically eliminates load changes, which ordinarily require a temperature controller with automatic reset.

Mixing and Blending—Where these operations are involved, often the primary concern of processing is obtaining a final product with desired proportions of two or more ingredients. Temperatures, pressures, etc., are usually of secondary importance. Therefore, fixed rates of feed of the starting ingredients are essential. If solids are involved, weigh feeders of the vibratory or belt type are ideally suited. Two or more feeders can be electrically interlocked so that a manual adjustment of one feeder automatically and proportionately adjusts other feeders in the series. Such equipment is widely used in the proportioning of cement ingredients, gypsum and clinker, ores, and so on. The savings which can be accomplished by a system of this type are exemplified by a large steel company which was faced with a need for much greater pig iron production. By blending the acid ore normally used with a high basic ore, it was possible greatly to cut down the amount of lime needed to neutralize the acid constituents, which in turn cut down on the coke requirements. The system resulted in eliminating the cost of a new 5-million dollar blast furnace and increased the effective capacity of existing furnaces by over 25 percent. Where liquids are to be proportioned, two orifice meters interlocked through a ratio controller, or mechanically or electrically interlocked proportioning pumps are frequently used.

VARIABLE FEED RATE

Crushing and Grinding—Underloading of a crusher or grinder results in the excessive production of fines and loss of power. On the other hand, overloading results in excessive power requirements, undue strain on the equipment, and the need for returning large lumps for further disintegration. These machines operate most efficiently under certain conditions of loading, which can be determined by measuring the power consumed, or in some cases, by means of an "electric ear." By interlocking a gravimetric feeder with one of these latter means of measurement, it is possible to obtain a maximum yield of the desired product with a minimum requirement of power. Constant rate feeding is not usually practical because the raw material varies in lump size, moisture content, etc.

Dosing—Feeding dosing agents into water, neutralizing agents to acid liquor flow, odorants in gas lines, etc., must be varied in accordance with the rate or composition of the primary flow. Where solid materials are fed, a gravimetric feeder interlocked with an orifice meter, or pH meter on the liquid flow, can be used to advantage. Where liquids are involved, the primary flow may be measured by means of an orifice or venturi meter and this instrument interlocked with a ratio controller or proportioning pump to produce the desired results. Automatic control of output of a proportioning pump in proportion to a process variable is a fairly recent development.

Distilling—The instrumentation of distilling processes is one of controversy. However, it is generally conceded that a constant rate of feed is desirable. Where a tower is fed from a heater or furnace, the flow is often interlocked with the temperature controller on the furnace. Where the effluent of one tower comprises the feed to a following tower in the series, the flow to the second tower is interlocked with a level controller on the preceding tower. In many cases, the rate of feed to the second tower is considered of much greater importance than the level in the preceding tower. In such cases, a level controller of the averaging type, which permits variations of level within extreme limits while causing a constant rate of effluence from the tower, is used. This arrangement diminishes the effect of surges in feed, which may be encountered in the first tower, to avoid upsetting the entire series. In many fractionating towers, the ratio of reflux to feed is also automatically controlled by means of a ratio flow controller.

Liquids being received at the plant can be measured continuously through positive displacement meters or semi-continuously by means of automatic tank scales. Solids such as coal, limestone, and sulphur, are measured continuously as received over totalizing belt conveyor scales or semi-continuously in automatic hopper scales. These scales are available with remote transmission, graphic recording and automatic printers and counters.

Automatic packaging scales which weigh out individual containers at a rate up to 60 per minute are available. Such devices are widely used in packaging small containers of salt, reagents, etc. Larger items, such as bags of fertilizer, barrels of chemicals, and drums of oil, are filled at a rate of about six units per minute with semi-automatic hopper or tank scales. These scales are also equipped with counters and printers to provide records for accounting.

PIPELINE DIGESTER FOR NITROCELLULOSE

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MANY ADVANTAGES over the old batch process for digesting nitrocellulose in water have come from the use of a pipeline type of reactor known as the Milliken continuous digester. This development was mentioned and illustrated in the author's recent article on developments in the lacquer industry, Chem. & Met., April 1945, p 110. Because reactors of this type are quite unusual for liquid phase reactions, further details of it are given here.

The batch process used chrome alloy units for smaller capacities, or steel autoclaves lined with acid brick for larger units, up to 6,000 lb. capacity, with operating cycles up to 16 hours. The continuous unit which replaced the batch units consists of approximately 0.8 mile of 4-in. dia. chrome steel tubing in numerous sections connected by long-sweep re-

turn bends. The first sections are steam jacketed, the intermediate sections simply insulated to hold the temperatures reached by the mass in the heated part, and the final section is provided with a cold water jacket to stop the digestion and cool the mass below the atmospheric boiling point of water. Since the digestion must be conducted under pressure to permit the necessary temperature, the required hydrostatic head on the entire system is provided by piping the mass from the discharge of the digester up over a 200-ft. tower, then down again to a final treatment and sampling tub. The tower was chosen as the best method of supplying back pressure, since other methods such as valves and pumps would be unreliable due to fouling.

Nitrocellulose is always in motion in the digester and well suspended in water, so that each fiber receives uniform treatment, producing a uniform viscosity much superior to the batch product. The continuous product has no opportunity to pick up contamination from brick and cement and the process eliminates gas pockets where overheating and possible explosion could occur. Labor required is less and much disagreeable work is eliminated. Furthermore, control is superior.

HOW BATCH UNIT PROCESSES ARE MADE CONTINUOUS

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BATCH OPERATION arises when, for any reason whatever, it is necessary to introduce to or to remove one or more materials from a unit operation or unit process in an intermittent manner, rather than in a continuous stream. The effect is that operating conditions are non-steady and the equipment is not in use all of the time. Hence it is less productive than it might be if the reason for requiring intermittent flow could be removed. Also, in many types of batch operation, the rate of production is not constant during any one of the batch cycles but decreases with time. Examples occur in the case of reactions, dissolving operations, absorptions, heat transfer applications and, in general, in any case where the driving potential decreases as the process continues. Other cases occur in catalytic reactions where the catalyst loses its potency, and in condensing and other cases of heat transfer, where scale builds up and thus increases the resistance of the heat transfer surface.

Sometimes it is possible to maintain the productive rate by increasing the rate of application of auxiliary services, such as by raising the temperature or pressure, but even when this is done, a point will eventually be reached where the cycle must be repeated. For example, it is reported[1] that a condenser in a distillery required 12 million g.p.d. of cooling water immediately after cleaning, but scaling was such that in six weeks' time the cooling water flow had to be stepped up to 21 million g.p.d. At this point it was necessary to shut the condenser down for cleaning and start over again. A continuous unit process was added, the so-called "threshold treatment" of the cooling water, which eliminated the scaling and made this unit operation also continuous.

As a closer approach to continuous processing, multiphase batch operation is sometimes employed, usually in conjunction with continuous steps, so as to maintain a continuous flow of at least one stream in the process. In this case one batch step is split into several overlapping parts, each carried out in a separate piece of equipment arranged in parallel with the others and operated overlapping so that the discharge will be consecutive and continuous. A variation is the countercurrent type of multiphase set-up, in which the several batch vessels are operated in series.

If the number of phases of a batch process could be increased infinitely, the process would in fact be continuous and the operating conditions would become steady. Thus better use would be made of time, that is, the idle time of the batch process, together with its filling and emptying time, would be eliminated, and there would be other advantages as well: Full use would be made of the potential capacity of the process; its controllability would be enhanced, owing to steady conditions; and the possibilities for heat and energy economy would be improved.

TREND TO CONTINUITY

Because of these and other advantages, many processes have been converted to continuous in the past and many more will be in the future. The advantages of the continuous method gained early recognition in certain fields,[2, 20] while in others, such as sulphuric acid, continuous operation has been used almost since the beginning. Today there is a growing recognition of the advantages and a better understanding of the sorts of process and product most suitable for continuous production. It is safe to state that where batch processes are now in use and continuous processing is at all feasible from an economic standpoint, the technical aspects of feasibility are being considered with a view to discovering the conditions or methods most suitable for continuity.

Merely changing a process to continuous by changing to continuous flow is, unfortunately, not always capable of bringing about the important advantage in use of time that was claimed for continuity in the preceding section. This is because, as has been pointed out elsewhere in this issue, a process employing continuous flow of materials is not necessarily a true continuous process. Ham and Coe[14] were the first to call attention to this fact, which has since been amplified by others.[5, 20] If the flow is through a series of tanks, some parts of the flow will pass through quickly, and other parts at progressively slower rates. The system is actually pseudo-continuous and the situation is not unlike that of a multiphase batch process in which some reactors are discharged too soon, and others too late. Only by increasing the number of series tanks to infinity will all the streams have the same detention time. With a finite number of tanks, the non-steady state of the process will mean that the reaction will be less complete than a batch process having a detention time equal to the average for the continuous process. On this account, either a larger tank volume or a longer period of operation is needed to equal batch output.

Actually, of course, the lost time in a batch process is such that in many continuous processes using even a rather small number of series tanks, the continuous tank volume need be no more, and may be less. In a few reactions it has been possible to get away from this pseudo-continuous character by "streamlining"[20] the unit so as to have the same effect as an infinite number of series tanks. In such a case the capacity per unit volume is, in theory, equal to that of a batch process, while the capacity per unit time is likely to be much greater. Unfortunately, for the present we must recognize that finite numbers of tanks or reactors in series are the best equipment available for most liquid phase uses, determining the optimum number from the over-all economics.

In this connection it is worth remembering that continuous operation is only one of the means for realizing more from a process, and that in many processes and operations we still lack the information on catalysts, reaction mechanisms and rates, and other surrounding conditions of the reaction which will enable productive limits to be reached. Only by the best combination of such conditions as temperature, pressure and agitation, and only by the best use of effective interphase contact, and (when pertinent) solvents, diluents, and means for removal of reaction products during the reaction, can the potentialities of a process be approached.

In the past, the tendency to convert to continuity seems to have been more pronounced with unit operations than with unit processes, although many of the latter can be cited and the trend is accelerating. The remainder of this article discusses some of the means that have been used for making unit processes continuous. In the main, dependence is placed on representative references, rather than detailed description.

The change from batch to continuous processing has been achieved by several different methods, of which the important ones are: (*a*) Eliminating the reason which made the use of the equipment periodic; (*b*) removing simultaneously the reaction products from the reaction mixture; (*c*) fitting the process to equipment which will maintain production on a continuous basis; (*d*) revising the operating conditions, and thereafter fitting the equipment to the process; and (*e*) developing new processes.

Many operations are batch in nature because of certain secondary factors. Scaling of condensers has already been mentioned. Somewhat similar is the evaporation of brine to make salt by the Alberger process[17] in which the scaling difficulty is eliminated by removing the calcium sulphate from the feed at the high temperature of 290 deg. F. Because of this purification of the feed, salt of high purity and specific surface is obtained. Furthermore, in the Alberger process, there is no need for periodic shut-downs (every 48 hours in one large plant[17]) to remove the mother liquor as in the vacuum-pan method.

IMPORTANCE OF CONTROL

Some processes are not yet adaptable to continuous operation because of the lack of suitable control methods. One of the advantages present in most continuous processing is its automatic control. Conversely, in making a process continuous a technique of control, preferably automatic and instrumental, should first be evolved.

Certain chemical reactions go to completion—practically speaking. Others, being reversible, reach an equilibrium state determined by the conditions employed. Such reactions can, however, be made to go to completion—and do so more rapidly—by removing one or all of the reaction products from the reaction mixture, preferably by physical means. For instance, one or more of the products of a liquid phase reaction may be distilled out if the reaction can be performed at the proper temperature, thus often allowing the process to be made continuous. As an example, in the manufacture of ethyl acetate the reaction vessel is topped by a fractionating column and the products, ethyl acetate and water, are removed at 70.5 deg. C. as a ternary azeotropic mixture (ethyl alcohol, 7.6; ethyl acetate, 84.5; and water, 7.9 percent). From this mixture pure ethyl acetate is obtained by a method called "hydroselection;" with part of the acetate returned to the reaction vessel as an entrainer in the distillation of the water.[12] In other esterifications where the ester is the highest boiling distillation component, other schemes must be used, for example as in the esterification of butylene glycol with acetic acid.[8] In making diethyl acetal by condensing two molecules of alcohol with one molecule of acetaldehyde, benzene is used as an azeotropic entrainer for the water formed. Water is carried to the top of the column in the form of a constituent in the ternary constant boiling mixture of alcohol, benzene, and water; diethyl acetal leaves the bottom.[18]

In certain reactions one of the products is removed for a reason other than completing the reaction. For instance, the nitration of benzene is not a reversible reaction.[26, 27] However, if water is allowed to remain and accumulate in the reaction mixture, it will act as a diluent for the nitric acid and the reaction will slow down with dilution until a point is reached when it stops altogether. Furthermore, diluted nitric acid acts as an oxidizing agent. Sulphuric acid can be used as a dehydrating agent, but in continuously operating units water is distilled out azeotropically ("partial pressure evaporation") by benzene.[27] In aromatic sulphonation, the effect of water on the reaction rate is similar to that in aromatic nitration. In the sulphonation of benzene, Othmer and Leyes[28] studied the reaction using kerosene as the entrainer for water for two reasons: One is that the reaction can be carried out at the high temperature of 160-170 deg. C., thereby increasing its velocity. Without the use of pressure this is equivalent to the application of a pressure of 6 to 8 atm. The second reason is that the volatility of the water is increased at higher temperatures.

Certain chemical processes are performed in batches because they involve a slow reaction. Some of these processes have been made continuous—in a relative sense—by a suitable multiphase arrangement, that is, by use of overlapping batch processes. Several years ago the multiphase arrangement was considered a feature in a modern alcohol distillery.[9] In the industrial alcohol plant of the New England Alcohol Co., Everett, Mass., it is reported that six fermenters are used, with a fermenting period of 50 hours.[9] Reports indicate that three to nine phases are used in Russian plants with a fermentation time ranging from 34 to 48 hours.[4] However, Kolachov and his co-workers[4] have reinvestigated the fermentation process and have shown that it can be completed in 5 to 7 hours in a strictly continuous unit. Also in the alcohol industry it has been shown[29] that a fermentable grain mash can be produced in 5 to 6 minutes continuously, compared to 3-4 hours batch.

Similarly in the soap industry, where batch processing consumes 3 to 7 days to complete a batch, the earlier attempts at continuity consisted in using the multiphase arrangement. However, recent reports[21, 22] disclose new continuous saponification and hydrolysis processes, some of which are already in commercial use. With high temperature alone a processing time of only 15 minutes has been claimed,[15] and even better[2] with high pressure also.

In heterogeneous processes also, where a solid phase is involved, simulated continuity of operation has been achieved by using parallel or countercurrent multiphase arrangements, for example, in extraction batteries, and the Houdry catalytic cracking process. Now it appears that many of these processes can be made continuous. For some the way has been cleared through the development of the principle of "fluidization" of a solid, as in fluid catalytic petroleum cracking.[25] (For history of fluidization and suggested applications, see Ref. 16.) Fluidization makes the solid free-flowing. Furthermore, it offers two features, both essential in continuous operation: (*a*) Increased rate of reaction because of the great increase in the interphase contact area; and (*b*) uniformity and close control of temperature (within less than 5 deg. F.) because of intense turbulence within the reaction chamber. The design of fluid catalytic units has been greatly improved since first announced in 1941.[24]

In certain cases the fluidization of the solid may not be practical. However, the process may still be made continuous through engineering developments, as in low temperature carbonization of coal,[19] in digesting pulpwood,[23] and in solvent extraction of vegetable oils.[5, 11, 20] A recent case is mechanical movement of the catalyst in the Thermofor cracking process.

In many instances the problem of conversion from batch to continuous processing requires a re-investigation of the process and operating conditions and of their effect on reaction rates, yields and the formation of byproducts. In slow reactions, rates can be increased by utilizing certain well-known principles.[10] To begin with, there are several possible ways of performing a given operation. Starting with the same reactants, theoretically there are an infinite number of paths leading to the same end products. It is necessary, then, to find a path of least resistance, that is, usually a suitable catalyst. Or, to obtain the same products, we may start with different reactants, and thereby use different processes. For instance, for the manufacture of phenol, starting with benzene, we may sulphonate it and then fuse the sodium benzene sulphonic acid with caustic soda (Monsanto-Catalin process[7]). We may chlorinate the benzene directly with chlorine and then hydrolyze the chlorobenzene under high pressure and temperature with a 25 percent excess of sodium carbonate solution (Dow process[13]). Finally we may oxidize it to phenol by way of chlorination with a mixture of hydrogen chloride and oxygen, followed by hydrolysis of the chlorobenzene with steam (Raschig vapor phase regenerative process[26]).

When the path and the process have been chosen, it is still necessary to select the best combination of operating conditions, as already noted. These conditions should be so manipulated as to bear their force at the desired point in the chain of steps which usually constitute a process. Where the processing rate is slow and is to be increased, attention should naturally be directed to the "bottleneck point." For instance, in a process which consists of a series of consecutive chemical reactions—as indicated by the reaction mechanism—the velocity of the process is controlled by the slowest step. Again, in a heterogeneous process involving the chain of mass transfer and chemical reaction (the latter either single- or multi-step), the velocity of the process is controlled by the slowest step. Furthermore, in a process involving simultaneous chemical reactions, effort should be directed toward suppressing the undesirable side reactions.

EQUIPMENT SELECTION

After the study of a process to determine the operating conditions for best results, it is necessary to select the equipment with which to perform the reaction on a large scale. It is the function of the equipment to prepare the ground for the successful performance of the reaction: it should therefore provide the means for maintaining temperature and pressure at specified levels, for adequate mixing and effective contacting, and for the removal of the products from the reaction mixture, if that is necessary. The reactor is, therefore, as much a part of the picture as the reaction and plays an important role in the qualitative and quantitative success of the process. Equipment design will, of course,

have to be based on data previously obtained, on data secured in the laboratory, and on pilot plant tests. The pilot plant tests should, therefore, be performed with those types of equipment which will be used later in actual production, selected because of an expectancy of most economical results.

Often equipment must be selected on the basis of past experience, and where experience is lacking and time is pressing, by a process of adaptation. Hence, the reaction may have to be made to fit the equipment. Tailor-made equipment is often a product of patient investigation. Fortunately, forceful trends at times provide the urge and stimulus for re-investigation of well-established methods, and for research to discover new ones.

SUMMING IT UP

Certain conclusions seem obvious: For example, at least in large scale production, continous processing is, in general, better than batch processing, while strictly continuous processing is preferable to the multiphase type. This last is especially true where the chances of thermal decomposition exist, because of localized over-heating or necessarily high operating temperature, with small time and temperature safety margins. For such processes the equipment should be of strictly continuous type and properly streamlined to eliminate dead spaces. Close and uniform temperature control is needed at all points, and the reaction mixture, once removed from the reactor, should be cooled rapidly by flashing, or by other means. The equipment volume should correspond closely to the minimum required, particularly when the material is thermally sensitive, or when uniformity of the product requires rapid and intimate mixing of one stream added to another.

In the preceding paragraphs we have discussed some of the general methods of approach used in solving the problem of converting a unit process from batch to the continuous type. Before closing, it should be emphasized once more that continuity is not an end in itself; it is one of the means to the more important end of greater production efficiency.

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PITFALLS IN WORKING OUT CONTINUOUS PROCESSES

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IN LAYING OUT a new continuous process, all engineers recognize the basic requirements of accurate weighing or metering of uniform ingredients, purchased to rigid specifications and processed under delicate controls to allow continuous operation. Engineering formulas, books on design and the engineering assistance furnished by equipment manufacturers help to form the plan which results in the production unit. The conception and design may be correct in so far as engineering principles, but there are often many small concealed details which can cause failure of initial operation or breakdown during production.

Points of possible mechanical breakdown, man failure, faulty timing and accumulative factors are difficult to determine. The log of experience may furnish examples which will suggest the form in which troubles may develop to plague the designer and operator.

My first experience with failure of a continuous process came during World War I. I was operating 10 carburizing furnaces on steel parts, mainly for British munitions, and one manufacturer of carburizing compound had sold me on his material because it was guaranteed to be uniform as a result of continuous processing. Suddenly results became erratic and some runs were extremely poor. The material was tested and found deficient in activating salt content. The manufacturer said that this was impossible and suggested a trip to the plant in Cleveland so that he could prove his point. What the trip actually proved was one way in which continuous processing can fail. When we climbed to the top of the building to start our inspection, we found the automatic metering and mixing machinery functioning perfectly, but fast asleep on a pile of bags was the laborer who was supposed to check on the condition of the supply. The activating salt bin was empty.

Screening operations are usually minor and non-critical parts of continuous processes but they sometimes act as trouble indicators and sometimes cause disturbance through their own failure. In the early 1930's, one of our large chemical manufacturers installed a continuous process for producing lithopone. A sculping screen was placed just ahead of the bagging operation. The product was very free from foreign material and the lumps were soft, so the screen was guaranteed to pass 98 percent of the feed. In operation it passed from 80 to 84 percent only, and I went to the plant to check up. On my arrival and for several hours thereafter the amount of oversize coming from the screen was very small and well within the 2 percent limit. The screen showed no signs of blinding and the tailings were low. Suddenly, things began to happen. The feed to the screen stopped for 32 minutes. Then the conveyor began to feed all the material it could carry. The feed swamped the screen and rolled over at a depth of about 4 in., which continued for about 20 minutes, with the tailings spout running full. Checking back we found that the large cyclone which collected the air-borne lithopone ahead of the conveyor feeding the screen was at times bridging at the bottom and cutting off the feed until sufficient weight accumulated to break down the bridge. A vibrator installed on the side of the cone corrected the trouble.

TRAPPING A CULPRIT

Another chemical manufacturer installed a continuous weighing, mixing, screening and packaging department for baking powder. Here again the screen, a single-deck unit, was just ahead of the packaging equipment. One morning the screen cloth broke and delivered unscreened material for some time before the break was discovered. It was necessary to open over 2,800 cans to insure that no unscreened material was shipped out. The solution of this difficulty took two forms. First, a double-deck screen was installed with a slightly bigger mesh, made with heavier wire, on the lower deck. This heavier lower deck screen was not normally exposed to the abrasion of foreign material and would, therefore, outlast the upper screen cloth. Second, the oversize discharge coming from the lower deck was fed into a small balanced hopper. Any discharge from the lower deck would overbalance the hopper and trip a switch, causing a red light to show.

During the past few years, many emulsification and dispersing operations have been introduced in continuous processes and have often caused trouble. Our protective colloids, stabilizers and dispersing agents are, of course, chemicals. Although they are not ordinarily regarded as entering into chemical combination with the other ingredients, some action is sure to take place. Usually, the laboratory development work establishes the correct amounts to use to allow for the chemical action and still have enough active material to achieve the desired results. However, in the laboratory the time interval between the addition of the material and the emulsification or dispersing action is usually longer than in the continuous process. This longer time interval is important as any chemical action after emulsification or dispersion may cause breaking of the emulsion or agglomeration of the dispersed particles. This was the cause of many failures in the first attempts to produce rosin soap asphalt emulsions continuously and also caused trouble in the continous production of clay asphalt emulsions. In the case of one clay asphalt mixture, it was found that an interval of from 4 to 8 minutes was necessary between the mixing of the ingredients and the mechanical emulsification.

GROWING PAINS

Transition from laboratory development to production may give rise to other difficulties. It is often necessary to change the order of addition of ingredients to achieve continuous production. Thus, in the laboratory, the conventional method of forming an emulsion can be followed. The stabilizer, dispersing agent or protective colloid can be added, say, to a lacquer solution and the water phase slowly added until the rough mix is ready for mechanical emulsification. It is the slow addition of the water phase which permits success. When large quantities are processed continuously the water phase cannot be added slowly to the entire amount of lacquer. Instead the water must be added quickly and continuously to its own portion of lacquer, and immediately emulsified. When the large amount of water first comes in contact with the lacquer phase, infinite dilution of the stabilizer exists and the water will not follow the lattice and produce the base for mechanical emulsion. The answer is to dissolve the stabilizer, protective colloid or dispersing agent in the water first. Then the concentration will be right at all times and the mechanical mixer or colloid mill can produce the correct physical condition.

If at all possible, laboratory tests should be followed by pilot plant operations before the move is made to go to plant-size continuous processing. Where the laboratory tests are not of long duration, trouble may be experienced in continuous production due to selective action of some part of the process on one or more of the ingredients. As an example, one manufacturer desired to add the grinding of one of his ingredients in glycerine to his continuous process. The material was a natural product varying from soft white to hard brown structure. Laboratory tests were made with a standard colloid mill fitted with a Carborundum rotor and stator and indicated excellent results. Full-sized equipment of the same kind was installed in the plant as part of the setup. The production started off nicely, the product being a light colored material, free from specks. However, after a short run the material began to darken and a multitude of fine specks appeared. Check runs proved that the action of the colloid grinding mill was selective, grinding the softer, light-colored portions of the material to the desired fineness but retaining the harder, dark portions in the head of the mill until their concentration became so great that the dark material was forced through without complete grinding. Changes were made in method of feeding, the grade and grit of stones, and the concentration of the glycerine but it was not found possible to overcome the selective action and the use of the colloid mill had to be discontinued.

Where wet processes are used, a liquid —water, oil, solvent or other material— often recirculates in the process, acting as a carrier or vehicle. If the raw materials carried by this vehicle introduce soluble impurities a build-up in impurity concentration can occur which may cut down the efficiency of the process or yield off-grade material. This condition may be hard to remedy. The best solution may be to secure raw materials free from the impurity if possible; otherwise the only other reasonably safe solution is to add a step to the process to treat the circulating liquid for removal of the impurity as it collects, perhaps by precipitation or distillation. Even this may not be immediately possible. A certain critical wartime polymerization reaction was designed for batch operation but converted to continuous. On starting up it showed the characteristic result of this difficulty: good initial production, followed by improper operation as the impurity built up. Pending discovery of what the impurity is, the process has been put back on a batch basis.

Unexpected electrical phenomena sometimes interfere with continuous processing. Thus, in dispersing operations, electrical charges on particles may cause them to re-agglomerate, sometimes forming agglomerates which are actually larger than the size of the particles of material as originally introduced. This trouble can sometimes be avoided by the addition of a protective colloid having a higher insulating value.

Many continuous processes embody grinding of one or more of the materials to the specified mesh, separation of the desired mesh being made by means of a screen, air separator, or wet classifier, the oversize being continuously returned to the grinder. Where this circulating load consists only of large sized pieces of material which otherwise check chemically and physically with the feed, no trouble is experienced, but where the raw material is an ore or other natural product which may vary somewhat in composition, the circulating load sometimes consists of very hard particles which may also be different in chemical composition. When this occurs, the circulating material will not grind at the same rate as the general feed and the hard, off quality, circulating load will accumulate to the point where it stifles production. Very careful examination of laboratory and pilot plant results is necessary to avoid this trouble.

As most of these pitfalls occur at the time of starting up the full scale production line, it is imperative that a well trained engineer be in charge of the initial operation. If possible, he should have with him the design, laboratory and pilot plant personnel during the first few days of operation. The new process should be producing material of the desired quality at or above the design rate of production before it is turned over to the production department.

HISTORICAL VIEW

(*Continued from page 105*)

study has been devoted to the continuous unit process of saponification which indicates that in the near future a change to complete continuous manufacture will be widespread in the industry (Flow Sheets, No. 137, 138; Shreve, pp. 606-610).

As one looks over the past in the chemical industry with the idea of seeing what has taken place in continuous manufacture, there stands out a number of aspects which must be solved before continuous processing can be put into effect. In the first place, instruments for the control of the chemical and physical changes must be available.* The present status is such that instruments that almost think are used by the modern chemical engineers. In the second place materials of construction to eliminate corrosion must be at the command of the designing chemical engineer. Examples of the newer materials are stainless steel, Duriron, rubber-lined equipment, Saran, Haveg and many others. These all enable the designer to change more easily from the batch to the continuous system because of less likelihood of breakdowns. Breakdowns or interruptions in any continuous process are extremely troublesome, usually more so than in batch work.

In the writer's own experience 35 years ago good labor in chemical factories could be had for $12 a week. Even realizing that the dollar went much farther then than it does now, there was less inducement to save labor than at present when labor is being paid a number of times this former weekly wage. With this increase in labor compensation, management has gradually been put under increasing economic pressure to save labor by the use of continuous processing, since mechanical instruments and mechanically controlled conditions favor continuous manufacturing and require less labor. With this decrease in labor there have been fewer people to object to night work and consequent enlargement of 24-hour processing. Finally, management has realized that by research, improved conditions for manufacturing steps can be evolved. All these have pointed to the ever wider use of continuous chemical processing.

* It is of interest to know that one man, Prof. G. W. Sherman, has continuously conducted a course in instrumentation for chemical engineers at Purdue since 1913.

TECHNICAL ASPECTS OF CONTINUOUS PROCESS SYSTEMS

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DEVELOPMENT or conversion of a chemical process to continuous flow invariably requires the reconstituting of batch mixing operations to suit the new conditions. This article is primarily concerned with the problems of initiating this change and is a review of the present practice, the equipment available, the theoretical aspects of batch and continuous methods of treatment, and the fundamental concepts on which any analysis of mixing should be based.

In a batch treatment the mass is held in the system until the required level of completion of the mixing and/or reaction has been reached. That is, the desired action progresses with time but not with distance through the equipment. In a continuous process the opposite condition exists and, in theory, there is no change in any process variable with time at any given cross section of the flow path, but only with distance along the flow path. Such conditions exist primarily in "streamline" flow, as in rotary kilns and sulphuric acid converters. In average mixing operations, however, there is some mixing along the flow path so that the distinction given is not entirely correct although it is usually close enough to the facts for practical understanding of the difference between batch and continuous processes.

Intermediate are the batch-continuous systems which can be identified by an intermittent flow pattern during some part of the process. They are often incorrectly identified as continuous because they yield a uniform stream of product. Two or more batch operations staggered in cycle to provide a constant feed to the succeeding step come under this classification. Many processes such as the manufacture of viscose and acetate dope for rayon yarn are best handled in this manner.

WHY BATCH PROCESSES?

Batch operations may be necessitated by a lack of knowledge of the art (preparation of "iron blue" pigment), a lack of suitable equipment (milling and blending of rubber with pigments, minerals and accelerators), unsatisfactory methods of controlling such variables as dilution, viscosity, reaction rate, etc., of critical reactions (growth of molds in the production of antibacterials), or because of better economy over continuous methods. The latter is frequently demonstrated in organic syntheses in which a fractional increase in yield of batch product outweighs any time or labor savings. Where these conditions do not exist, continuous mixing operations can normally be expected to increase plant productivity, reduce labor costs and provide a more uniform product.

CONTINUOUS MIXING SYSTEMS

In the following discussion only those systems have been considered which are amenable to continuous treatment, and an attempt has been made to list and classify all of the equipment types in common use. The most suitable classification of mixing operations[1,2] is based on the functions to be performed on the material such as simple physical mixture, physical change, dispersion, etc. In the present analysis, however, the simple grouping of continuous systems under batch-continuous, recycle, concurrent, and countercurrent based on the material flow diagram, appears to be adequate.

Batch-continuous has been described above as a partially continuous process having one or more batch steps. A recycle system consists of a mixing vessel, with a closed external circuit through which the mass of material is constantly recirculated. A small portion of raw material is continually fed to, and an equivalent portion of product bled from, the external circuit. In contrast, concurrent and countercurrent are once-through operations with the material progressing in sequence through the equipment to the next process step. In the latter, the flow of one component in the system is counter to that of another.

This broad classification is further subdivided into combinations of the three physical states in which the material may exist. Continuous systems are first illustrated with typical equipment, followed by a discussion of the specific machines of each type in common use.

In the selection and design of mixing equipment, however, a more rigorous analysis of the individual case is necessary, covering such factors as physical characteristics of the materials and their mixture, physical change to be promoted, reaction level and holding time required, rate of feed, etc. Although considered an individual unit operation, the mixing step is usually in conjunction with others such as heat transfer, crystallization, absorption, extraction, etc. It may therefore be defined as the operation of continuously redistributing the discrete parts of a mass of material so that a complete homogeneity of the mass is approached and any correlative unit operations are promoted. These are the concepts on which the following illustrations are based. Further reference to equipment design is included below.

Batch-Continuous—In liquid-liquid and liquid-solid systems it is sometimes necessary to follow a continuous operation with a surge or storage reservoir (Fig. 1) to provide a supply of material for subsequent batch treatment. The old method of liming cane sugar juice prior to intermittent batch defecation is an example. This is now being supplanted by modern continuous clarification equipment.

In the reverse assembly (Figs. 2 and 3) two or more batch units may be arranged with staggered operating cycles to provide a continuous feed, direct or through a surge reservoir, to subsequent steps. Although sometimes handled continuously, the most common method of preparing filled asphalt for the coating machines is illustrated by Fig. 2. Similarly Fig. 3 is typical of the several steps in the preparation of cellulose acetate and viscose solution for the yarn spinning machines. There are no common examples of gas treatment by this system but a tunnel kiln (Fig. 4) may be mentioned in which hot gases flow continuously past the intermittently moved solids. The vertical lime kiln or iron ore blast furnace (Fig. 5) might also be included in this category as a solids decomposition system involving a solid, liquid and gas phase. However, no part of this operation is truly continuous.

RECYCLE ARRANGEMENTS

Recycle—Recycle systems accomplish one or more of several functions not attainable in once-through designs. They may provide for recirculation of the material:

1. Through a zone of high shear intensity thereby increasing the retention time in that area;
2. Through auxiliary equipment to obtain a secondary physical change such as heat transfer;
3. Through a separation step to remove one of the products and thereby improve the reaction equilibrium or prevent undesirable side reactions;
4. Of one phase to increase its utilization by a sluggish reaction;
5. To provide a product containing a minimum of unreacted constituents.

The last is simply a means of reducing short circuiting but this can be more efficiently accomplished with an improved mixer design giving more complete homogeneity of the vessel contents, or by dividing the operation into a series of stages.

Gas or vapor-liquid systems on the recycling principle using baffled, packed, spray, orifice or bubble cap columns (Fig. 6) are numerous. In the hardening of vegetable oils and in some organic halogenations and hydrogenations the gas is recirculated by external means to give better utilization. In the hardening of oils, however, this method has become obsolete and is rapidly being replaced by equipment providing internal gas recirculation.

The Glover and Gay Lussac towers of a chamber sulphuric acid plant are good illustrations of systems in which the liquid phase recycles. Many examples utilizing the solid-gas phases can be found. Sometimes it is the gas and sometimes the solid phase that recycles. The unreacted gas recycles through a fixed solid catalyst in the pressure synthesis of ammonia (Fig. 7), and the solid catalyst recyles after regeneration in the fluid catalyst petroleum cracking process (Fig. 8). Another solid recycling process is the Thermofor catalytic cracking process (Fig. 28).

Liquid-solid and liquid-liquid systems, particularly the latter, demonstrate each of the reasons mentioned above for the use of recycling. Fig. 9 illustrates the simplest circuit with a pump, alone or with orifice plates or nozzles included in the pipe line for additional turbulence. Raw material is continually added at *A* and product removed at *B*. Used to provide a regular return of the material to the mixing zone and to yield a product containing a minimum unreacted fraction, it is a displacement system and does not produce a uniform mixture throughout the system. Homogeneity is obtained in designs similar to Fig. 10 in which the bulk of the material is uniformly dispersed through the mixing vessel, the pump and external conduit being incidental. The reaction can take place more rapidly in this state than in laminar division. Alkylation of a hydrocarbon is an excellent example of the latter design, with the external circuit including an exchanger for the removal of exothermic heat.

The last modification of this type, incorporating an outside separation step, is shown diagrammatically in Fig. 11. This is typical of a hydrocarbon isomerization process using liquid catalyst. An analogous operation, combining solid, liquid and gas phases, is the oxidation of spent doctor solution (Fig. 12), with removal of oxidized lead and recycling of lead sulphide slurry. Catalytic synthesis of ammonia (Fig. 7) uses outside separation for removal of the liquified ammonia, while fluid catalyst cracking employs cyclone separation of the catalyst. Examples involving liquid-solid phases include the closed-circuit wet grinding system and the several precipitation reactions in which the solid is separated and removed.

A flow diagram of the blending and grinding of solids such as cement and ores in ball or tube mills (Fig. 13) shows air as the circulating medium and includes cyclones or screens for separation of the solids to size.

CON- AND COUNTERCURRENT

Concurrent—The next two sections cover the more apparent true continuous once-through systems. In most gas or vapor phase processes a concurrent mixing operation can be found somewhere in the flow diagram. It may consist of a simple straight pipe or a series of loops or may include orifice plates (Fig. 14), valves, or nozzles in the line. The mixing is in streamline with the gas flow.

Similarly, with liquid phases, the same combinations of pipe loops, nozzles, etc. (Fig. 16), may be used. More efficient operation is obtained with a single vessel (Fig. 17) having a mixing element properly designed to produce homogeneity of the mass. For further improvement of the mixing of the components and to reduce short circuiting, the system is divided into several stages. This is accomplished by connecting several units in series (Fig. 18), which is typical of the causticizing of soda ash and the manufacture of strong phosphoric acid, or by subdivision of a single unit with suitable partitions as in Fig. 19. The latter is exemplified in continuous lube oil blending, asphalt filling, and the doctor and acid treating of hydrocarbons. The last two are illustrative of the unit operation of mixing, per se, having as its function the unit operation of extraction, as in the solvent recovery of butadiene from admixture with butane. In this case correct machine design is based on the best mixing theory to obtain mass homogeneity, maximum interphase contact and minimum short circuiting.

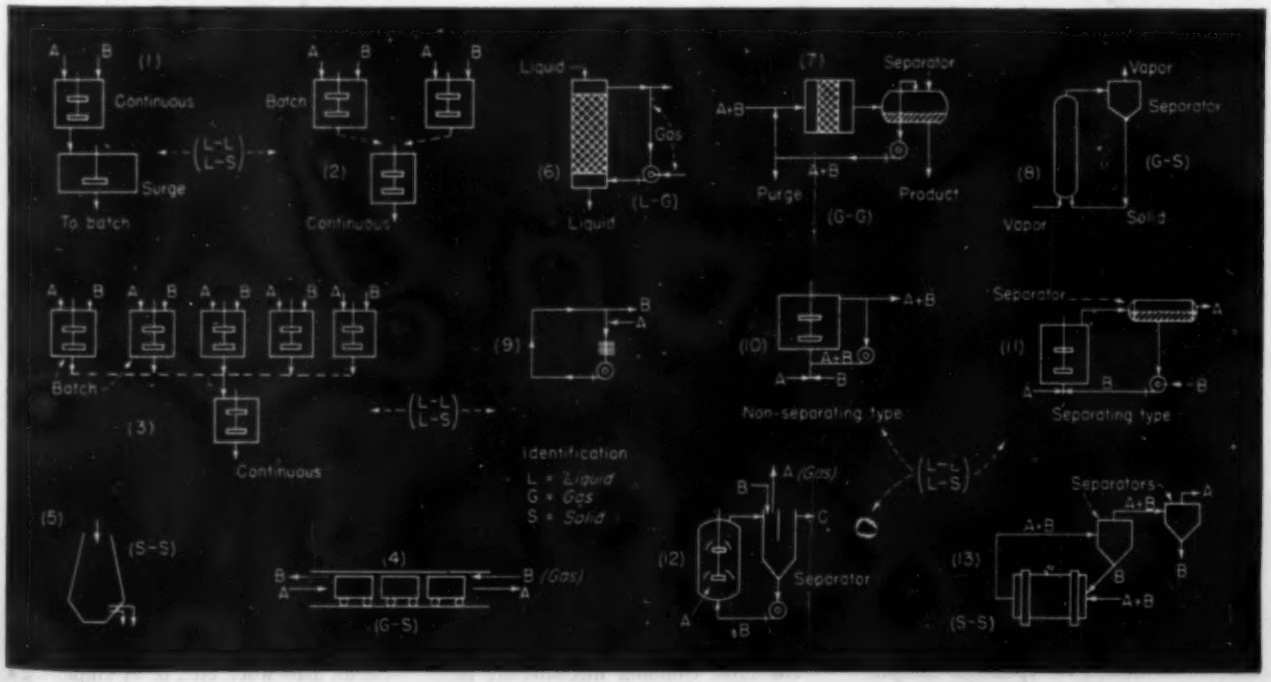
The baffle plate column or packed tower (Fig. 20) is also commonly used for liquid-liquid systems. For a liquid and a gas phase, two or more mechanical absorbers may be connected in series on the liquid stream with the gas fed in parallel (Fig. 15) as in the oxidation of asphalt and the ammoniacal leaching of nickel ore, or with the gas fed in series as in the carbonation of dolime.

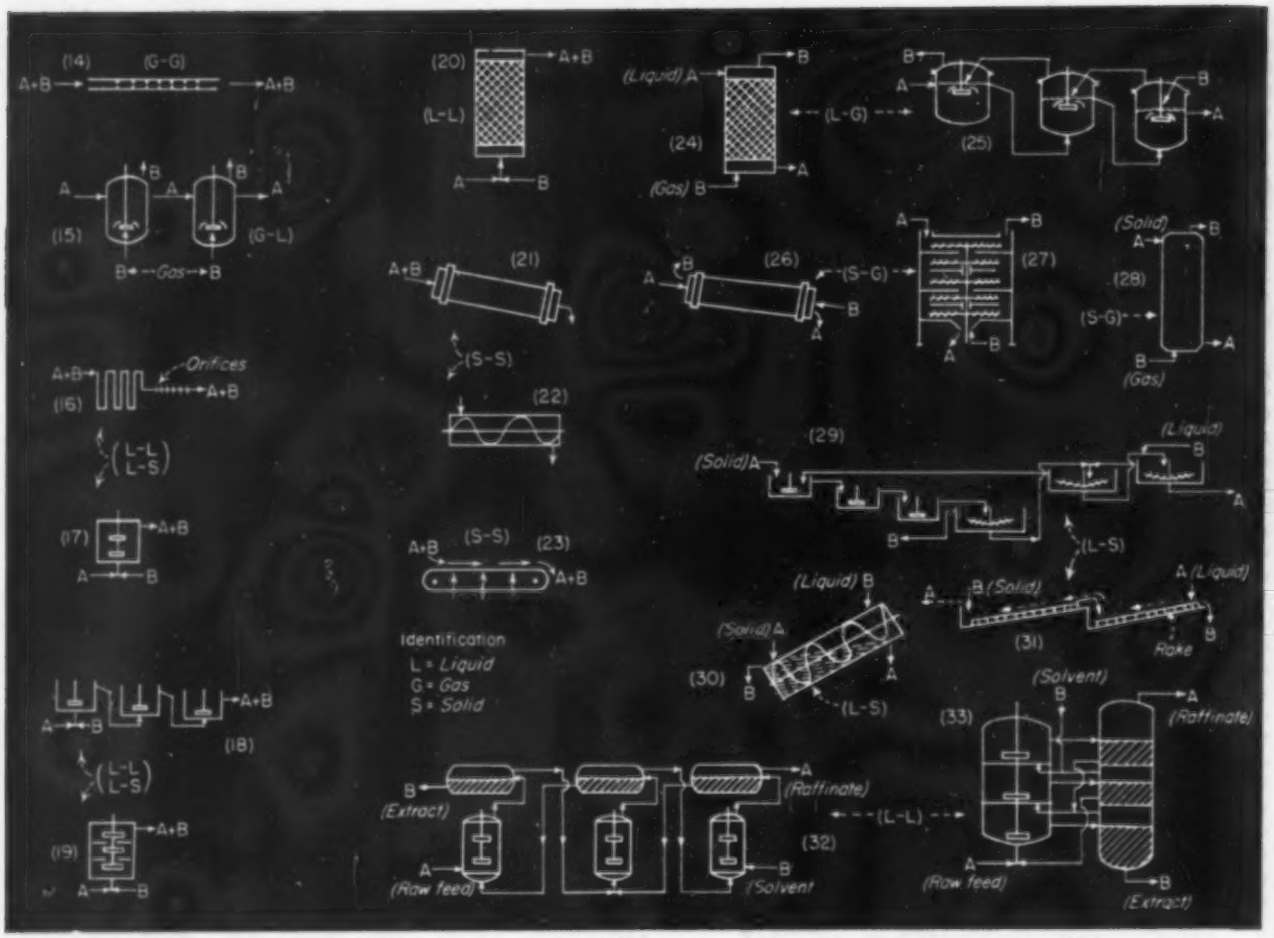
For the continuous blending of solid mixtures (and in some cases their combustion or heat treatment) the systems in use can be represented by the rotary kiln type (Fig. 21) the ribbon trough (Fig. 22), and the Dwight-Lloyd roaster or pyrites burner (Fig. 23). All operate on the displacement principle.

Countercurrent—The last and most complex classification is that of the countercurrent system. Commonly employed in this service, the tower (Fig. 24) may be designed for bubble caps, Raschig rings, Berl saddles, etc., when treating a gas and a liquid, and for perforated plates, baffles, nozzles, or packing when handling liquids.

Liquid-gas reactions are likewise performed in mechanical absorbers (Fig. 25). The stripping of hydrogen sulphide from zinc sulphide solution and the carbonation of calcium-magnesium hydrates are typical examples. In these, as in several of the liquid-gas systems previously mentioned, all three phases are involved. The solid may be present as a catalyst (copper chloride sweetening of gasoline), solute

Figs. 1-13—Equipment arrangements commonly used in batch-continuous and recycle systems





Figs. 14-33—Equipment arrangements commonly used in concurrent and countercurrent systems

(ammoniacal leaching of copper ore), or as a precipitate (lime carbonation).

Rotary lime and cement kilns (Fig. 26) are representative of systems in which a solid being oxidized or calcined flows counter to the hot gases. The same functions are served by the multiple hearth furnace (Fig. 27) for the drying or roasting of solids. Another type is the vertical kiln (Fig. 28) used in the revivification of bleaching clay and for regenerating the catalyst in the Thermofor catalytic cracking of oil. Here the gas phase rises through the descending solid mass.

The Dorr C.C.D. flow diagram (Fig. 29) typifies a liquid-solid system in countercurrent flow for the causticizing of soda ash, cyaniding of gold ore, etc. It should be noted that the mixers in this process operate concurrently. Another example, the vertical or inclined screw (Fig. 30), is applied in the solvent extraction of soy meal and is exemplified also in the spiral classifier. The countercurrent washing (and sometimes extraction) of large mesh solids and of friable materials such as silica gel is accomplished in multi-deck or series rake classifiers, as shown in Fig. 31.

Two systems are in common use for contacting liquids with liquids countercurrently. Fig. 32 represents a series of individual mixers in combination with separation chambers. In Fig. 33 the mixing stages are combined in a single vessel and are connected to separation compartments in an adjacent tower. Typical operations are the Duo-Sol process of solvent extraction and the removal of mercaptans from a hydrocarbon with aqueous caustic.

EQUIPMENT TYPES

The equipment types described above are illustrative of specific continuous systems and in many instances represent a class of mixer of which there are several varieties. These classes are further subdivided, below, on the basis of the material phases. Batch types are omitted.

Gas-Gas—Starting with gas or vapor mixtures, the most common design is the "Y" tube (Fig. 34) used in oxyacetylene torches. Next is the straight pipe with or without baffles or orifice plates (Fig. 35), loops, valves, or orifice nozzles (Fig. 36). One or all of these types may be found in every gas or vapor phase process. For instance, the catalyst chamber in a contact sulphuric acid plant is a mixer with the catalyst bed acting as baffling.

Liquid-Liquid—For liquid mixtures the open trough with over-and-under baffling (Fig. 37) is probably the simplest type and is used for the flocculation of alum in water and sewage treatment. Next is the pipe line, straight or in loops (Fig. 38), or having orifice plates, nozzles, valves, or other means of introducing a turbulent zone in the flow pattern. Applications are numerous.

The most common mechanically powered device is the centrifugal pump (Fig. 39), which provides a high degree of turbulence but only a "flash" residence time. A Flomix (Fig. 40) installed directly in the pipe line is a similar instantaneous mixer but provides an increased, controlled turbulence. The colloid mill (Fig. 41) also operates with a short holding time but, by shearing the mass through a small clearance between surfaces moving at high relative velocity, it accomplishes the special functions of disintegration and emulsification. This service is also performed by homogenizers using pressure, rather than moving surfaces, to shear the material through fine orifices.

The next step toward greater efficiency is accomplished by installing the mixing element in a vessel having more than a "flash" retention time. The tank may be equipped with any of the several mixer designs—exemplified by simple paddles or gates (Fig. 42), propellers without or with a draft tube (Fig. 43), turbines without or with stator blades (Fig. 44), and variations of these types. The above listing is in the order of increasing effectiveness in liquid phase treatment. If it is necessary to increase the holding time to obtain the desired reaction level and reduce short circuiting, the operation is staged by placing two or more vessels in series, by using a baffle plate tower (Fig. 45) or one packed with coke, Raschig rings, Stedman screens, glass wool, etc., or by employing a

staged mixing vessel (Fig. 47) of which the Turbo-C-C-Treater (Fig. 48) is a specialized type. These staged units or single vessels in series give the best guarantee of maximum detention and minimum short circuiting.

Liquid-Gas—The packed tower (Fig. 46) is also used for liquid-gas systems, as is the spray tower (Fig. 49) and the bubble cap column (Fig. 50). All have particular advantages for specific applications.

A mechanical improvement of the spray tower is the multi-stage Feld scrubber (Fig. 51) and the more recent Turbo-Saturator (Fig. 52). The former has been used in the absorption of sulphur dioxide, hydrogen sulphide, etc. The Saturator is in service as a gas scrubber.

Two designs for shearing and scrubbing the gas phase are the fin plate type (Fig. 53) described by Cooper, Fernstrom and Miller[3] and variations of it, and the Turbo-Gas Absorber (Fig. 54). The latter is extensively used for all kinds of stripping and absorption work. All of these units may be used singly or in a series.

Liquid-Solid—Progressing to liquid-solid systems the most satisfactory and useful mixer is the turbine in a baffled tank (Fig. 55), although the paddle or gate (Fig. 42) and the propeller in a draft tube (Fig. 43) are frequently employed. Under certain conditions of vessel shape or for physical specifications such as the suspension of high-density solids or for the dissolving of solids such as nitrocotton, the turbine and stator ring (Fig. 44) mounted on the tank bottom is the preferred design.

A specialized type particularly adapted to the handling of fibrous solids is the Centri-Cone (Fig. 56). The ribbon trough (Fig. 57), the inclined screw (Fig. 58), and the pug mill (Fig. 60) provide similar but distinct means of dispersing dense slurries which are not pumpable. The Dorr agitator (Fig. 59) incorporates the principles of the thickener scraper mechanism and uses an air lift and rotating launder to provide movement and distribution of the solids through the machine.

Solid-Solid—The standard machines for solid mixtures are the inclined rotary kiln (Fig. 61) and the horizontal rotating cylinder (Fig. 62), represented by the barratte, and ball, rod, and tube mills. The Votator (Fig. 63) is specifically designed for fat and grease treatment, having the primary function of heat transfer.

Solid-Gas—Several classes of solid-gas phase equipment have been previously noted, including a countercurrent type (Fig. 64), exemplified by the Thermofor reactor or kiln, and a concurrent type (Fig. 65), of which an example is the fluid-catalyst cracking system.

Solid-Liquid-Gas—Specific mention should be made of three-phase systems. They have previously been referred to as occurring in many liquid-gas reactions. The solid may be present as a catalyst, a reaction product, or as one of the raw materials treated. The first two have already been illustrated; a well-known example of the latter is froth flotation for which there are numerous specialized designs.

TESTING TECHNIQUE

In developing data for use in the design of continuous agitating equipment there are a number of points that must be considered for best results. One of the most pertinent is the limitation on the use of small scale laboratory experiments. Such tests can be used in investigating the chemistry involved, but they cannot be relied on for data regarding agitator type, required energy concentration, nor agitator efficiency. Extrapolation of operating data obtained with small scale equipment is subject to considerable error, even when the translation is of average magnitude. This is due to the relatively insignificant power requirement for agitating small batches, which introduces error in the recording of small variations, and is due also to the fact that on this small scale the inefficiency usual in laboratory agitators is readily concealed by excessive power application.

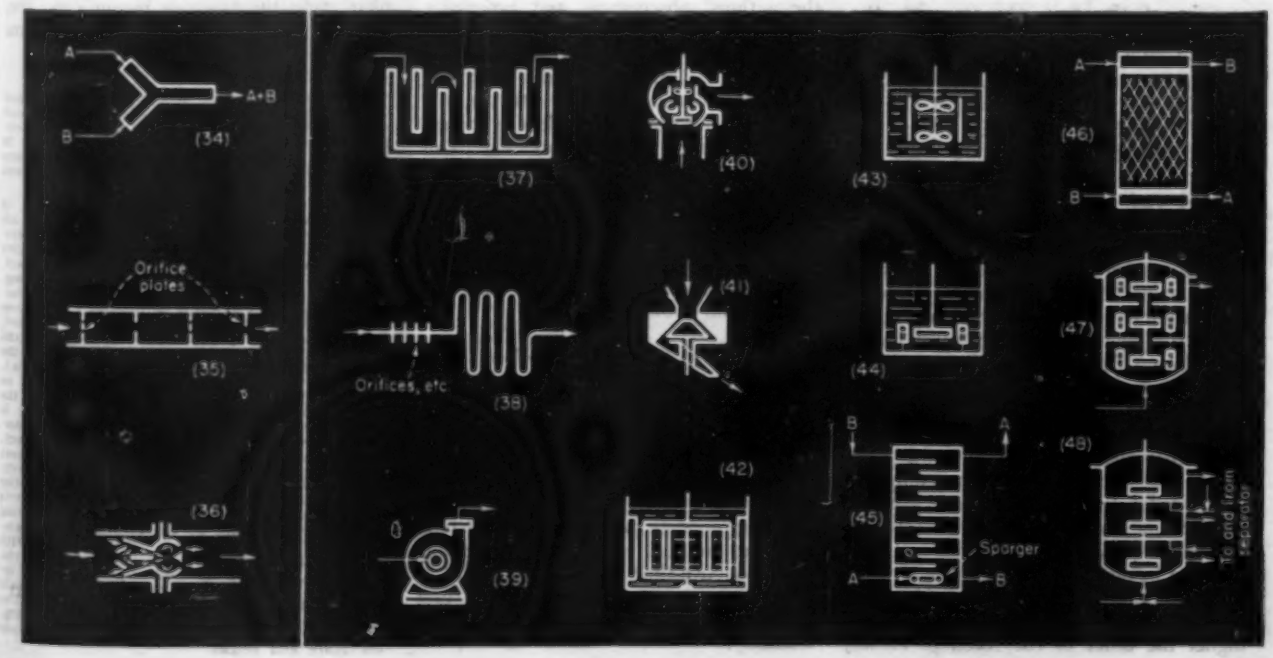
Pilot plant equipment, therefore, should be used wherever possible for data required for extrapolation. The type of mixer to be used in the pilot plant deserves careful consideration. Since circulation patterns differ with various types, but must be considered in the commercial design, the same type agitator should be used as projected for the commercial plant. Another reason for employing the same type is the difficulty and the possibility for error inherent in extrapolating data obtained with one agitator to another of different characteristics. This practice demands a greater than normal safety factor and introduces the probability that over- or under-sized equipment will result.

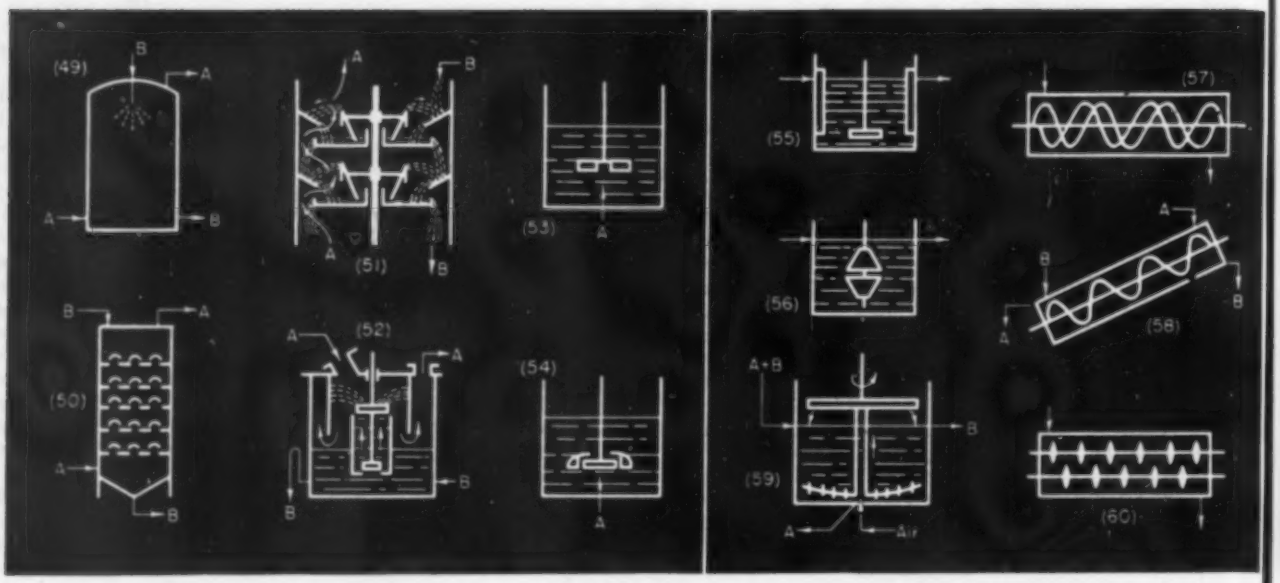
Also, the relation of tank shape, size and dimensions to the impeller diameter has a pronounced influence on the mixing effect obtained. The proportioning of the equipment as an integrated unit should be carefully done. An oversize mixing element in a small tank detracts from the value of the data, since the engineer is concerned with the determination of the point of maximum efficiency. Excess agitation serves no useful purpose; to the contrary it obscures the data and complicates the extrapolation problem.

EXTRAPOLATION OF DATA

The theory of short-circuiting in continuous flow mixing vessels has been investigated by Ham and Coe[4], MacLean[5], MacMullin and Weber[6], and Brothman, Weber and Barish[7]. The mathematical analyses of the first three references and the theories and equations developed by their authors were based on having the tank contents absolutely uniform, as a result of instantaneous mixing, so that random samples would not differ in composition from the average of the whole

Figs. 34-48—Devices commonly used for continuous gas-gas and liquid-liquid mixing





Figs. 49-60—Devices commonly used for continuous liquid-gas and liquid-solid mixing

tank. Brothman, Weber and Barish based their analysis and derived equations on what might be termed a displacement mixing system, with recirculation, as shown in Fig. 9. Here the analysis was based on the rate of circulation produced by the pump or other mixing element. Their approach is novel and convenient but it appears their conclusions are not entirely consistent with those of MacMullin and Weber.

RETENTION IN SERIES TANKS

The effect on retention time of a flow of material through a series of tanks in which mixing is taking place has been explained elsewhere in this issue. In summary, it has been shown that the outflow from such a series contains material which has remained in the system for lengths of time varying from extremely short to extremely long, and that the distribution of these holding times for the various portions of the flow changes with the number of tanks in the series. With only one tank, the bulk of the material is largely short-circuited; that is, it is held for less than the average or nominal holding time (i.e., volume/flow rate), but as the same total volume is split into more and more tanks in series, the short-circuiting is reduced and the variations tend to approach an average which is the nominal holding time. This means that for a continuous system of tanks to be approximately equivalent to a batch system of equal volume from a holding time standpoint, the continuous system must be divided into a large number of series tanks.

It appears then that the degree of non-uniformity in a continuous system depends on the subdivision of the system, but the effect that the non-uniformity will have on the efficiency of the system, compared with a batch system of the same volume, depends in any case on how closely the particular reaction that is carried out may come to being linear with respect to time. Most reaction rates decrease with time, but the decrease is more marked, the higher the order of the reaction. Hence, unless a reaction is actually linear in type, it will take longer in a continuous system than in a batch system to bring about the same degree of reaction completion, so that a continuous system will have to be larger per unit of reaction time, or its output will be less. Furthermore, the higher the reaction order, the greater will be the disparity between the two systems. But for any particular reaction order, the disparity can be decreased by increasing the subdivision of the system.

In the extrapolation of data to commercial equipment, the authors have for years used the formulas and curves derived by MacMullin and Weber to describe these effects of short-circuiting. The data have been found to be adequate and accurate within acceptable limits of error in the determination of number and size of continuous mixing vessels. With certain reservations, discussed later in this article, the authors' observations and experience agree with MacMullin's and Weber's comment, "From the foregoing mathematical analysis it is clear that a series of mixing or reaction vessels operated with continuous flow is not nearly so efficient as though the vessels were operated batchwise. This is either in respect to the daily capacity or output, or in respect to the degree of mixing or reaction accomplished. It also follows that to accomplish a given output at a given degree of treatment, the continuous system is bound to be larger in volume and more costly."

EFFECT OF DEAD-TIME

On the other hand, Brothman, Weber and Barish claim as advantages of continuous systems over batch ". . . the elimination of all 'dead-time' in charging and discharging batch types of equipment and in bringing an accumulated mass of material to appropriate processing levels of temperature, pressure, etc., thereby increasing the productive time of the plant." and "In most cases a greater productivity per unit volume of tankage per unit of time (is realized)."

The conclusions reached by the above group of workers appear to be contradictory. However, they can be largely reconciled if in the interpretation it is considered that MacMullin's and Weber's statement is based on the premise that only a small fraction of the complete batch cycle is dead-time* (charging, heating, storage, discharging), while Brothman's statements are based on a batch cycle having a large dead-time fraction.†

When dead-time is eliminated, as in a continuous process, it is possible for the process to be considerably less efficient than a batch process and still produce an equal or greater amount of product per day (although not in the same time as the active time of the batch process), with the same or less equipment volume. This statement introduces the consideration that when the batch dead-time exceeds a certain critical percentage of the complete cycle, the flow rate through the continuous system having the same volume

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* MacMullin's and Weber's formulas and curves[6] showing volumetric efficiency of batch compared to continuous systems for equal decomposition do not consider dead-time. However in their text and examples, dead-time is taken into account in the determination of relative tank volumes.

† The examples used by Brothman (*Chem. & Met.*, Sept. 1943, p. 113 ff) to illustrate his methods of design of a continuous agitating system contain two computational errors which give results that appear to show that, contrary to fact, production is increased by a decrease in staging. Actually, correctly employed, the Brothman formula gives results agreeing quite closely with those of MacMullin and Weber. In the examples cited, the reaction completion S was inverted and should have been 1/3 rather than 3. Also the sign of the reaction rate exponent (lambda), which is negative, was incorrectly employed as positive. However, a possible disadvantage of the Brothman formula lies in its sensitivity. It is claimed that it is necessary to work to a considerable number of decimal places to assure accuracy, whereas certain terms in the formula can at best have only an approximate value. Thus, the circulating rate or capacity of an impeller or propeller is an important term in the formula, but charts and formulas at present available for estimating this factor can only be considered approximate. In practice the circulation rate fluctuates with swirls, eddies, surges and turbulence, while viscosity has an appreciable effect and should be included in the evaluation. Specific gravity should not have an appreciable effect on circulation. The Brothman nomograph does not take into consideration the important design characteristics of blade curvature and height.

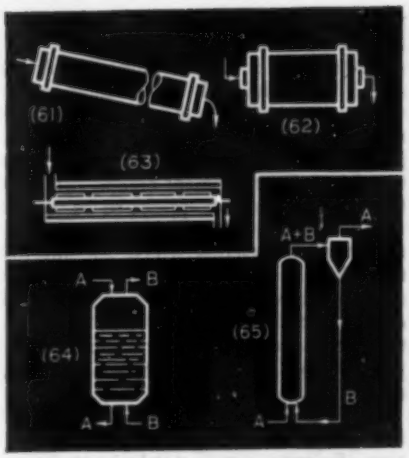
as the batch system can be decreased to the point where the effect of the short-circuiting will be offset by the longer holding time, the reaction completion level will be the same, and the same daily output will be obtained.

Examples of batch processes with exceptionally long dead-time periods are blending of lube oils and cutting of asphalt with naphtha. The operations are performed in storage tanks of 30,000 bbl. capacity and more. The actual mixing, or "reaction," time required to effect the blend might be only 1 hour out of every 48, the rest of the time being dead-time of charging, storage, and discharging. Such a process can be changed over to a continuous one through the use of a single 100-gal. continuous agitator, and with suitable proportioning equipment and pumps can deliver a finished product direct to tank cars or barreling plant.

As an illustration of a process involving a relatively long reaction time and short dead-time period, the dissolving of a non-readily soluble salt can be used as an example. For an average size tank of 2,000 gal. the charging and discharging time would represent only a small fraction of the complete cycle. Without any change in tank volume or internal modification, the use of the single batch tank in a continuous dissolving process would result in a large part of the added salt being discharged undissolved from the system. This is due to the requirements of the process, which demand that the agitation be at least sufficient to establish uniformity of the tank contents. As a result, a portion of the salt would always be circulated to the discharge port after a detention period representing a fraction of that required for solution. Such a continuous system as this cannot be expected to deliver a solution conforming to specifications at batchwise capacity unless it is modified.

These modifications might be any one or all of the following depending on the complete set of conditions that exist: (1) Increase agitation. (In many heterogeneous reactions, however, the agitation effect on reaction velocity reaches an optimum beyond which the increments of improvement are not justified by increased equipment and operating costs); (2) Decrease short-circuiting by increasing the tank volume, dividing the tank into stages by means of partitions, or operating several tanks in series; or (3) Separate and recycle the undissolved solids.

As already noted, the extent to which staging is used to diminish short-circuiting is an important factor in determining the volume of continuous equipment necessary. By staging is meant the division of the tank into several mixing zones or compartments through the use of partitions placed normal to the direction of flow of liquid through the system and having ports to allow liquid passage between stages. The same effect is obtained by using a multiple of tanks operated in series. (See chart, p. 102.—Editor.) Under certain conditions of dead-time and staging, a change from a single-stage continuous tank to a multiple-stage unit, will enable its volume to be equal to or less than that of a batch tank which has an equal daily output.

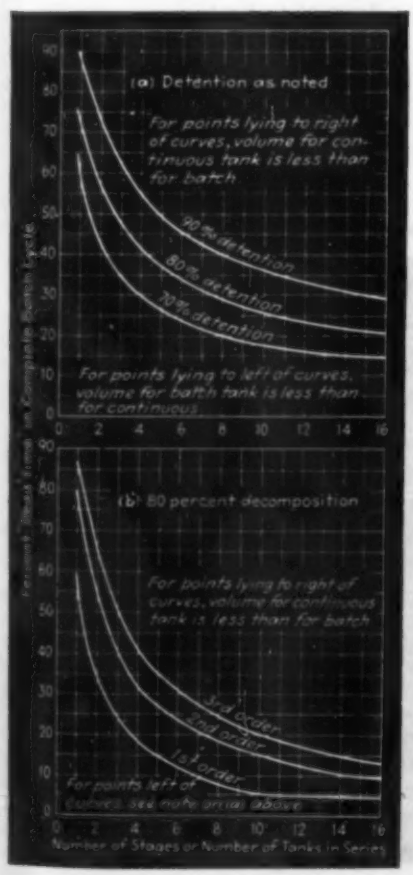


Figs. 61-65 — Devices commonly used for continuous solid-solid and solid-gas mixing

As a guide in predicting whether the continuous tank volume will be greater or less than batch tank volume for same output capacity, the curves shown in Fig. 66 *a* and *b* are presented herewith. The data used in plotting the curves are based on MacMullin's and Weber's formulas.* Each curve represents the locus of comparative operating conditions under which a staged continuous tank or series of separate tanks will have the same volume as a batch tank for equal daily output. The coordinates used are the number of stages or number of tanks in the series and the percentage dead-time in the complete batch cycle.

Reactions involving only solids have mixing patterns to which the liquid short-circuiting theories do not apply. In continuous solid mixers, dryers, burners and ribbon mixers, the material is not uniformly mixed so as to have homogeneity throughout the entire charge. Theoretically, in such systems, there exists a regulated progression of material from inlet to outlet and consequently a better control of detention time can be exercised than is possible in liquid agitators.

Fig. 66—Curves for determining comparative volumes of batch and continuous systems


(a) Detention as noted
For points lying to right of curves, volume for continuous tank is less than for batch
90% detention
80% detention
70% detention
For points lying to left of curves, volume for batch tank is less than for continuous
(b) 80 percent decomposition
For points lying to right of curves, volume for continuous tank is less than for batch
3rd order
2nd order
1st order
For points left of curves, see note under (a) above
Percent Dead-Time in Complete Batch Cycle
Number of Stages or Number of Tanks in Series

The curves in Fig. 66*a* are based on continuous tank volumes that will hold 70, 80 and 90 per cent of the flow for at least the reaction time obtained in the batch unit. The curves in Fig. 66*b* are based on 80 percent decomposition (reaction completion) for both batch and continuous systems and are plotted for first, second and third order reactions.

When using these curves, if the point located by the coordinates representing batch dead-time and number of continuous stages should fall on the appropriate curve, the continuous tank volume will equal that of the batch tank. If it falls to the left, the continuous tank volume will be greater and to the right, less.

For example, assume that the reaction is one that requires 80 percent of the material to be held for at least the batch reaction time and that in batch operation the dead-time represents 47 percent of the complete cycle. Referring to Fig. 66*a*, for equal daily output the point on the graph corresponding to the above conditions falls on the curve if a three-stage tank is used. The three-stage tank, therefore, would have same volume as the batch tank. A two-stage tank moves the point to the left of the 80-percent curve, indicating that a tank larger than the batch tank is required. Comparison of a four-stage tank moves the point to the right of the curve, indicating that a continuous tank smaller than the batch tank can be used. The curves in Fig. 66*b* are used in the same manner as illustrated in this example, substituting reaction order for percent decomposition.

Should the comparative operating point be to the right or left of the curve, the continuous tank volume can readily be calculated, since its volume is directly proportional to reaction time.

In the example given, the batch dead-time would have to be 56 percent and the reaction time 44 percent to have a two-stage continuous unit with equal tank volume. However, our batch condition specified 47 percent dead-time, and 53 percent reaction time, so that a two-stage tank would have to be 53/44 the size of the batch tank for equal output.

Note: In the curves no correction of tank volumes has been made to take care of the difference in "outage" or unused volume. This correction can readily be made by decreasing the continuous tank volume by the percentage outage that exists in the batch tank and increasing the volume of the continuous tank by the percentage outage it might require.

MIXING ART

The analytical and engineering approach to a mixing problem is required to complete the prerequisites for economical and successful continuous process equipment design. So far, basic continuous systems and equipment types have been described and classified. These are the engineer's tools. The extrapolation of laboratory and pilot plant data to commercial equipment for tank specification, through the use of the mathematical analysis referred to previously represents his technique. Analysis and diagnosis of process mixing requirements can be termed the art involved.

An exact analysis by the engineer is as essential to accurate equipment design as is a correct diagnosis to proper treatment of a patient by a physician, though there are a few instances where process and

patient have pulled through despite the treatment administered.

Agitation is a phenomenon difficult to define and evaluate. It is an operation for which there is no standard of measurement, such as other unit operations enjoy. Hixson[1] states, "There is no truly rational basis for equipment design; although the over-all operation appears to be simple it is invariably found to consist of a number of related factors which are difficult to evaluate quantitatively. Since the general objectives are so varied and the range of conditions so extensive and involved, the formulation of a general, unified and practical expression for agitation does not appear possible."

Material systems comprising liquid, solid and gas phases require for optimum reaction efficiency, not a standard circulation and energy pattern, but one "tailored" to the process requirements. Only by appreciating these requirements can successful equipment be specified.

An analysis of an agitating application reveals it to be a physical means utilized to effect a concrete measurable result, physical or chemical. The result desired might be an entirely different unit operation or combination of operations. It might be heat exchange; materials transfer (elevation of heavy solids in slurry form to overflow); pumping (draft tube type agitators or positive head impellers); disintegration and dispersion (two-phase systems). Such an analysis develops the question of which unit operation is to be regarded as the primary one and the one for which the circulation and energy patterns should be suited.

At present, field experience in the investigation of all types of mixing problems under all sets of conditions is about the only available source for acquiring the necessary analytical ability. However, in this section an attempt will be made to convey graphically the basic mixing concepts applying to fundamental processes.

It would appear appropriate at this point to digress slightly and suggest that mixing investigations conducted by industry and the universities attack such problems from the viewpoint of determining the ideal flow and energy patterns required for optimum results in the various chemical and physical processes. Development of the mixing characteristics of various agitator designs, which appears to be the current trend, should be supplementary. After a true and, if possible, measurable flow and energy pattern has been developed for a process the equipment should be designed to fit it, rather than the present tendency of suiting the process to the equipment characteristics and using excessive power to offset the presence of design deficiencies.

CIRCULATION AND ENERGY

Circulation and energy patterns have been referred to and will be used to describe the ideal mixing conditions.

The term "circulation pattern" refers to the direction of the fluid flow lines, induced by the agitator, in all planes of the mixing chamber.

These descriptive terms are being used rather than the customary equipment characteristics of power consumption, agitator discharge velocity, impeller or propeller circulation capacity, etc., since the latter describe the apparatus and not the process requirements. Our viewpoint should be directed to the principal problem of determining what conditions must exist for optimum reaction. When these are decided, the agitator characteristics can then be utilized to establish these ideal conditions, but with control and discrimination, in the same manner that the processing factors, temperatures and pressure, are controlled.

Primarily an agitator in producing a mixture is called upon to perform the following physical changes: To circulate the materials in the system; to subject the materials to attrition action (This is an adjunct of circulation); and to subject the materials to mechanical shear and disintegration by the rotor or auxiliary equipment.

These functions are variable and controllable and their intensity is dependent on the agitator design characteristics, and operation. Circulation, attrition and shear intensity must be suited to the process requirement. For example, an agitator used for emulsion preparation should produce an energy pattern different from that required for a crystallizing step. The former requires high shear energy to effect disintegration. The latter requires primarily liquid recirculation with no zones of shear so crystal size can be controlled.

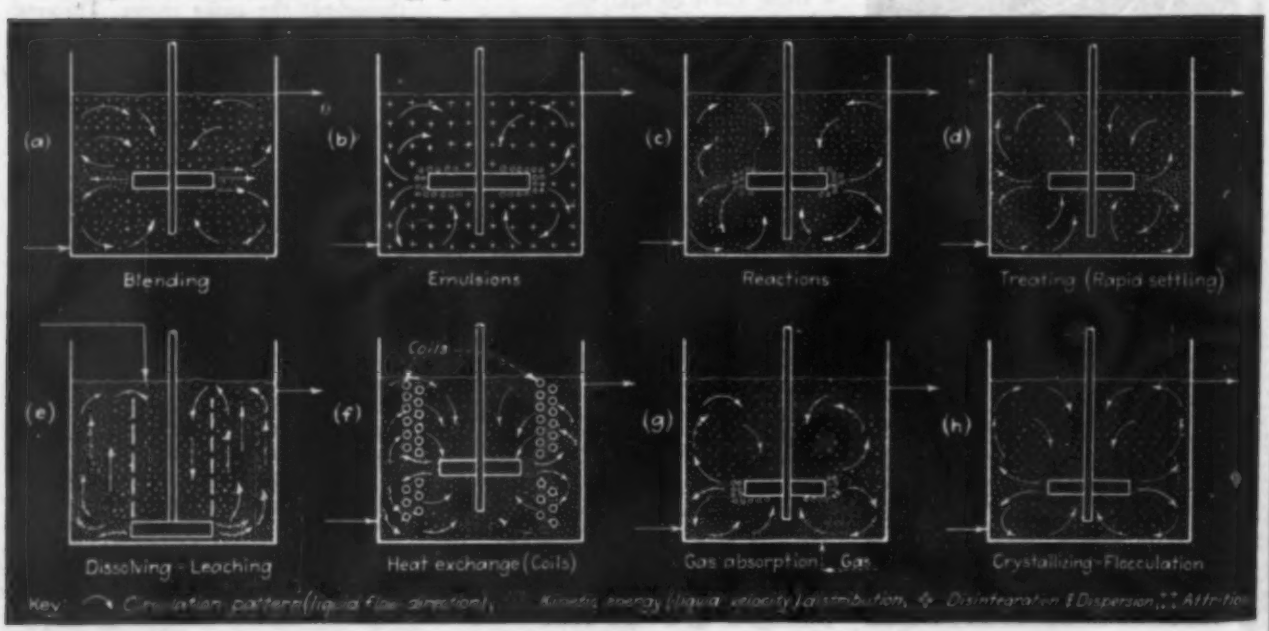
Sketches in Fig. 67 are intended to show the basic circulation and energy patterns for the principal processes. No attempt is made to provide quantitative information. However, the density of shading is intended to convey an approximate idea of the relative work input or energy concentration. This can only be general since density and viscosity affect this requirement.

Those applications involving two or more basic operations will have as their primary pattern the one representing the maximum total energy input. For example in a gas absorption application with fine catalyst present, the gas absorption pattern controls. Equipment designed for that function has adequate circulation capacity to distribute the solids uniformly. On the other hand, in a leaching application involving heavy coarse ore in the presence of a readily soluble gas such as SO_2, the controlling pattern is that for the leaching and not the one for gas absorption.

Referring to Fig 67:

(a) Blending of Miscible Liquids—This function of mixing is one of the simplest to perform and relatively little power is required. The circulation pattern should be such that the plane of the stream discharged from the agitator is normal to the direction of flow of liquid through the

Fig. 67—Circulation and energy patterns for optimum results in various operations requiring agitation



vessel. This "liquid baffle" prevents short circuiting of unmixed components. A vertical circulation pattern should also be established and a swirl condition controlled. The latter, if excessive, promotes laminar segregation.

(b) Emulsions of Medium to Low Viscosity—This process requires the operations of disintegration and dispersion. To this should be added the necessity for reduction of the disperse phase to specified particle size during the first application of the shear energy. In many emulsion formulations, the ultimate particle size has been found to be established during the initial disintegration. Repeated circulations through the agitator mechanism do not reduce the size of the stablized drop.

In view of this, high shear energy effect should be concentrated in the vicinity of the agitator rotor. The energy will be sufficient to impart the necessary circulation to assure uniformity of discharge.

There are techniques, however, whereby attrition or interfacial liquid friction is utilized to produce a fine emulsion, such as the Continental method. In this reverse phase process high viscosity is attained during one stage. The viscosity promotes the attrition effect. In such cases, high circulation increasing the interfacial friction effect is ideal, and energy concentration at the impeller, though required, is not so vital as in the first instance.

(c) Reactions: Liquid-Liquid; Liquid-Solid— Many workers have investigated the kinetics of chemical reaction velocity and the controlling factors. In the literature can be found an abundance of mathematical formulas proposed to evaluate this phenomenon. However, there does not appear to be complete agreement among the investigators nor general application of the formulas and hypotheses. This no doubt is due to the broad scope of the term "reaction." Reactions fall in various categories and orders. In this discussion, the illustration is restricted to those chemical reaction processes where reaction products are formed and reactant concentrations change.

The investigators do agree that diffusion and interfacial area are controlling factors. Therefore, the energy and circulation patterns should be such as to promote these conditions to the maximum during the transit time of the material through the mixing vessel.

The circulation pattern should have high velocity streams in the horizontal and vertical planes. These streams should exist throughout the entire mass and many recirculations through the agitator should be provided. Intimate dispersion for maximum interfacial exposure is also required. It is necessary to so direct the circulation streams that no segregation of reactants can occur. Segregation might promote undesirable side reactions and also might cause back leakage of heavy components.

(d) Treating: Liquid-Liquid; Liquid-Solid— This is also a reaction process and pertains to heterogeneous systems where the primary requirement is extraction as in caustic treating of gasoline, polymerization in acid treating of petroleum products, or adsorption illustrated by clay bleaching of oils. Roughly they may be classed as physical changes rather than chemical reaction processes.

The patterns required are essentially the same as for the preceding *reaction* process except in those cases where subsequent separation economies call for reduction of shear or disintegration. This decrease in energy concentration must be balanced by increase in circulation effect. This is particularly true in such processes as acid treating where colloidal "pepper" flocs may be formed or in caustic and doctor treating where emulsions are likely to occur. The pattern shown for crystallizing is typical except a higher recirculation rate than flocculation requires is needed to prevent reactant separation.

(e) Dissolving and Leaching: Liquid-Liquid; Solid-Liquid—This process is also classed as a heterogeneous reaction but is treated here as a separate process since it has characteristics not present in those reaction processes discussed above.

For light, miscible liquids, the pattern shown for blending is suitable since the mixing requirements are comparatively simple.

When handling liquids and solids, however, greater energy and increased circulation must be provided. The solids must be uniformly suspended and they must be scrubbed by the solvent to obtain the maximum diffusion at the interface. All parts of the mixing vessel must be agitated and localized eddy currents eliminated.

In those cases where heavy, incompletely soluble, coarse solids are present, it is necessary to establish a circulation pattern of vertical currents of sufficient rising velocity to overcome the falling velocity of the solid. Otherwise solids will accumulate and plug the apparatus. Draft tubes are sometimes used with impeller and propeller agitators to assure that effect.

(f) Heat Exchange: Liquids—High velocity over coils or jacket shell is required. Dead unmixed spots should be avoided. These sometimes appear between coil and tank shell if insufficient clearance is allowed for proper circulation in that annular section.

FILM "THINNING"

Since ΔT is the driving force and is affected by film thickness, it is necessary to keep the stagnant film on jacket or coil surface as thin as possible. Also, this film should be constantly changed, and all parts of the liquid should show uniform temperatures without a rising gradient in the vicinity of the jacket shell. Swirl promoting laminar segregation must be avoided.

The pattern shows the ideal circulation in a tank with a coil. High velocity streams wash through the coils. Multiple coil banks should be staggered so as to baffle the wash stream and prevent streamlining. Maximum coil surface is thus utilized.

No shear concentration at the rotor is needed unless the process requires dispersion for a concurrent operation in the vessel.

For a jacketed vessel, Fig. 67e for dissolving shows the typical pattern that applies.

(g) Gas Absorption: Liquid-Gas; Liquid-Gas-Solid—The pattern shown applies to equipment utilizing mechanical means for gas disintegration and dispersion rather than orifices or porous plates. Since gas absorption is a heterogeneous type reaction, the diffusion rate must be promoted. This requires maximum interface, bubble distortion, redispersion of stabilized bubbles and maximum detention in the liquid.

Ideal conditions prescribe maximum liquid head consistent with process and mechanical limitations, intensive shear and disintegration energy applied to the entering gas. The circulation pattern should be such as to extend the gas path and to retain the gas in the liquid as long as possible.

Also bubble aggregation and the tendency for the gas to channel through the liquid should be prevented. Maximum energy appears in the lower section of the vessel with high recirculation rates for repeated passages of the bubbles through the rotor before rising.

Swirl should be corrected, since the centrifuging effect developed by that action will cause the light gas to separate and collect at the swirl axis.

The pattern shown in Fig. 67g does not apply to those applications involving small volumes of easily soluble gases. An example of such a process is given in an earlier part of this article.

(h) Crystallizing and Flocculation: Liquid-Solid—Gentle currents reaching to all parts of the mixing vessel and of sufficient volume to prevent settling and assure uniformity are required. No area of high shear or disintegration energy should exist. Under *treating* a special operating requirement was described, which is typical of a flocculation step.

The illustrations are intended to show only the most desirable circulation and energy patterns which experience has shown are required for optimum process efficiency. No attempt is made to specify or recommend any particular type of agitator. In most cases any of the various agitator types can be used in the design of the agitator required to produce the patterns shown, but it will be found that operating costs will prove some types to be inefficient in certain applications.

The patterns apply specifically to continuous processes. The same patterns can also be used as a guide for batch processing. However, in the latter, the necessity of delivering a uniform product to discharge and of preventing short circuiting is absent. As a result, the energy input can be less for batch than for continuous processes where circulation is concerned, but where shear, disintegration and attrition are necessary operations, the continuous process patterns will apply.

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CONTINUOUS MIXING AND REACTION EQUIPMENT DESIGN

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IN THEIR BROADEST classification, continuous devices for mixing, dissolving and reaction can be divided into two types, variously known in the case of the first type as single-pass, plug flow, displacement or "streamlined;" and in the case of the second type as multi-pass, "non-streamlined," or pseudo-continuous. The first type, which we call here single-pass, includes all continuous mixers and reactors in which all portions of the effluent, practically speaking, have remained in the system for the same length of time and have not recirculated within the system, thus being "single-pass." The second type, referred to hereafter as multi-pass, includes those kinds of mixing and reaction equipment in which, because the material recirculates within the equipment itself, various portions of the effluent have remained in the system for varying lengths of time. In some equipment in this classification the flow path is fairly well defined and the flow can rightly be considered as making few or many "passes" through the equipment before discharge. In others the flow path is not well defined but the retention time of various parts of the effluent may still be defined by probability type calculations and can still be considered as having made varying numbers of passes before discharge. Regarding equipment of the second type, this article is mainly concerned with systems in which the multiple passages are in well defined paths, but as will be shown the same methods can be applied to other systems.

SCOPE AND AIMS

In this article, the aims will be several: to present the advantages and disadvantages of single- and multi-pass types; to illustrate a few forms of each type; and to show by examples how the design calculations may be made. For that purpose, in Tables I, II, III and IV we have assembled a considerable number of equations which were derived by rigorous mathematical means from well established concepts of physical chemistry, fluid mechanics and process equipment design. In the interests of brevity the derivations are omitted here* and in addition, the actual computations are mostly omitted from the examples, although the principles followed are explained and the data given in each case so that those who wish to follow the computations in detail may easily do so by substitution in the designated equations.

Typical single-pass systems are illustrated in Figs. 1 to 4. Such systems are common in vapor and solid phase continuous reactions, but less common in liquid phase and heterogeneous systems. An outstanding advantage of such systems is that they achieve steady-state conditions of operation almost instantaneously and the period of transiency, that is of unsteady operation, is short. In multi-pass systems, however, the period of transiency from start-up to steady state is necessarily longer since by definition the effluent of the system will have spent various times in the system from a minimum to a virtually infinite period. Examples of such systems are illustrated in Figs. 5 to 7.

The characteristic of transiency period is important not only in starting up, but also if the system must be purged of any contaminants that may be introduced, or if changing raw materials necessitate changes in process conditions. The time of a single pass is obviously the purging time of a single-pass system, but in multi-pass systems the recycling of newly fed material along with that already there means that greater than average retention time is required to achieve virtually complete displacement of the existing contents of the system. Purging time, then, is the time needed to displace by new flow any specified percentage of the system contents existing at the time when the new flow is introduced.

Some of the most important criteria that are used in deciding between single- and multi-pass continuous systems may be mentioned:

Single-Pass Systems—Situations favoring single-pass systems include fast reactions; those having a short induction period, that is, a short period of the kind shown by certain reactions which appear quiescent for a time before proceeding actively; those not requiring a high degree of mixing; those where frequent starts or purges may be needed; and those where little deviation from the average holding time can be permitted, as in many polymerizations. Other cases include liquid phase reactions where undesirable effects are produced by reaction products already in the system; processes that do not require removal of large amounts of exothermic heat during reaction; and those where sharp changes of pressure and/or temperature may take place.

Multi-Pass Systems—Situations favoring multi-pass systems include slow reactions; those with a long induction period; those with a critical mixing problem; and without serious transiency and purging problems. Other cases include processes where considerable deviation from the average holding time is allowable; where the presence of reaction products already in the system is either unimportant, or exerts a desirable auto-catalytic effect; where considerable amounts of exothermic heat must be removed during reaction and the temperature buffering effect on the feed of cooled recycled material is desired (as in Fig. 5); and finally, where sharp changes in temperature and/or pressure, which in a multi-pass system would needlessly upset the economic energy balance, are not encountered.

SINGLE-PASS REACTORS

For handy reference Table I lists the relations between throughput, extent of reaction completion, and system volume, which we use for the commonly encountered types of single-pass continuous reactor and mixer problems. This listing, of course, is not exhaustive.

In the tabulation we employ the following principal terms to classify reaction and mixing processes: Constant volume systems, variable volume systems, infinite contact reaction systems, and finite contact systems. A constant volume system is defined as any mixing or reaction process in which a zero or negligible change in the space occupied by all the components and/or phases, which make up the active system, occurs at any time during the mixing or reacting cycle. A variable volume system, on the other hand, is described by a significant change in volume. Infinite contact systems are those in which contact between the reactants is theoretically established on the ionic, atomic, or molecular level. A finite contact system is considered here to be any system in which the phenomenon involved occurs as a function of the area of contact, i.e., an interface phenomenon.

In the section of Table I devoted to constant volume, infinite contact systems, we have given the V_s-R-S relationships in terms of molar quantities and in concentration units. The form of the equations using the molar quantities will be particularly helpful where liquid phase reaction systems demonstrating a significant change in volume characteristic are encountered. In such instances, the volume factor, when it appears in the equation, may be given the log mean value between the initial and the final volumes of the system. Generally speaking, variable volume systems are met solely where gases or vapors are present as reactants under constant pressure. All of the equations have been derived on the basis of isothermal reaction conditions.

Some of the design factors, other than the volume of the system, which are important to the design of single-pass continuous systems, will be brought out in the course of the following illustrative examples.

ILLUSTRATIVE PROBLEMS

Problem 1—A batch reaction system of 1.43 gal. containing 0.525 lb. of $NiSO_4$ and 0.45 lb. of Na_2CO_3 (the carbonate being present in excess of stoichiometric requirements) is reacted to 97 percent completion at 100 deg. F. in a period of 3 min. Accurate dynamometer measurements indicate that the mixer shaft-horsepower over the reacting period averages 0.05 hp. It is desired to design a single-pass reactor system to achieve 99 percent completion of reaction and to react a flow of 1,000 lb. of $NiSO_4$ per hour. The reaction is a second order type and demonstrates a constant reaction volume characteristic. Equation (3) in Table I can be used by substituting $t = 3$ min. for its equivalent, V_s/R. Solving for k, the reaction velocity constant, where $V_s = 1.43$, $t = 3$ min., $N_{A_0} = 0.45 \div 106 = 0.00425$ mol, $N_{B_0} = 0.00339$ mol, $N_A = N_{A_0} - 0.97\ N_{B_0}$ and $N_B = N_{B_0} - 0.97\ N_{B_0}$, we find that $k = 1.118$ gal./(min. mol).

If 0.525 lb. of $NiSO_4$ is contained in 1.43 gal., it follows that an input of 1,000 lb. of $NiSO_4$ per hour would require a flow of $R = (1{,}000 = 1.43/(0.525 \times 60$ min.$) = 45.2$ g.p.m. Also, $N_{B_0} = (45.2/1.43)(0.525/155) = 0.105$, and $N_{A_0} = (45.2/1.43)(0.45/106) = 0.134$ lb.-mol per min.

Using Equation (3) for a constant volume, infinite contact, second order system where one of the reactants is present in excess of stoichiometric requirements, we find that, where $R = 45.2$ g.p.m., $k =$

* To those interested the authors will be glad to supply on request copies of a monograph that they have prepared, containing the full derivations of the final expressions and information on the various assumptions involved. This monograph also contains a section on the application of the equations developed in the authors' article in our April issue (*Chem. & Met.*, April 1945, pp. 102-6), to continuous blending equipment. That article, dealing with the kinetics of mixing, presented expressions that can be applied simply and directly to single-pass continuous mixers and are applicable somewhat less simply to multi-pass continuous mixers. Address Mr. Brothman at 114 E. 32 St., New York.—*Editors.*

1.118, N_{A_o} and N_{B_o} are as given above, $N_A = (0.134 - 0.99 \times 0.105)$ and $N_B = (0.105 - 0.99 \times 0.105)$, then $V_R = 204$ gal. which is the capacity of the reactor.

It will be observed that, since the value of k, the reaction velocity constant which we used to determine the reactor volume, was obtained with a work-input for agitation of $0.05 \times 3 \div 1.43 = 0.105$ hp.-min. per gal., for a throughput rate of 45.2 g.p.m., we would have to provide for a work-input rate of $45.2 \times 0.105 = 4.74$ hp. for the size of reactor computed.

Thus, if a single-pass reactor of the type shown in Fig. 4 were used, the total drop across the orifice manifold, excluding normal friction losses in flow through the container, would have to be approximately $4.74 \times 33{,}000 \div (45.20/0.134) \times 70 = 3.64$ ft. pressure drop where the apparent average density of the reaction mass is 70 lb. per cu. ft.†

Problem 2—Let us consider the design of a unit for the production of acetone by the catalytic conversion of acetic acid vapors. This process, first reported by Squibb about 1896, involves the passing of acetic acid vapors, at 400-500 deg. C. and atmospheric pressure, over a barium oxide or similar type catalyst. The reaction is given as:

$$2\,CH_3COOH \longrightarrow (CH_3)_2CO + CO_2 + H_2O$$

and is therefore seen to involve an increase in vapor volume as the reaction progresses from 2 mols of reactant to 3 mols of product.

Let us assume that we wish to produce 1,000 gal. per day of acetone with an overall reaction yield of 92 percent using barium oxide as the catalyst and maintaining a temperature of 400 deg. C. and a pressure of 1 atm. in the system.

ACETONE REACTOR

The working design equation is Equation (12), Table I. Referring to the equation, it is obvious that all terms necessary for calculating V_R are known, with the exception of the reaction velocity constant k. In this type of reaction, although the continuous large scale unit is run at constant pressure, it would be extremely difficult to run a batch reaction under the same conditions. A constant pressure batch reactor, for a varying volume system, would necessitate some sort of gas-tight sliding piston or accordion-like arrangement, such as a gasholder. Fortunately, the value of the reaction velocity constant k is relatively independent of pressure, and is a function only of temperature and the units employed. We may, therefore, run a batch reaction at constant volume to determine k, making certain that the temperature of the batch is the same as will be employed in the continuous system.

For this particular acetic acid to acetone reaction, although the authors have not done any laboratory work themselves, the results of a small scale experiment were described by Squibb (*J. Soc. Chem. Ind.*, Vol. 15) in which he used a rotary still to convert 1,700 lb. of acetic acid to acetone with a 90 percent yield in 126 hr., the still being 2 ft. in diameter and 12 ft. long. Although the literature does not state whether this was run as a batch reaction (at constant volume and increasing pressure), or as a small scale continuous reaction, the latter is more probable, and will be used to calculate k. In this case $V_R = (\pi/4)D^2L = (\pi/4) \times 4 \times 12 = 37.8$ cu.ft.; $T = 400$ deg. C. $= 752$ deg. F. $= 1{,}212$ deg. F. abs.; $P = 1$ atm. $= 2{,}120$ lb. per sq.ft.; $R_g =$ the gas constant $= 1{,}543$; $N_{A_o} =$ mols entering per min. $= 1{,}700/(60 \times 126 \times 60) = 0.00375$; $N_A =$ mols leaving per min. $= 0.1 \times 0.00375 = 0.000375$; and $\psi =$ sum of coefficients of products $= 1 + 1 + 1 = 3$. Substituting in Equation (12) we find that $k = 1{,}310$ cu.ft./(min. mol.).

Now, for our particular design problem the desired production = 1,000 gal. acetone per day = 6,560 lb. per day = 113 lb.-mol per day. Since 2 mols of acetic acid is required for 1 mol of acetone, and with 92 percent reaction yield, the necessary input of acetic acid can be calculated from Equation (12) where $N_{A_o} = 2 \times 113/(0.92 \times 24 \times 60) = 0.171$ lb.-mol per min., $N_A = 0.08 \times 0.171 = 0.01368$ lb.-mol per min., and R, T, P, K and ψ are the same as before. In setting these values in Equation (12) we find $V_R = 2{,}180$ cu.ft. Thus we see that a reactor with a volume of 2,180 cu.ft. would be required. The choice of actual length to diameter ratio to be used would depend on many factors, such as available floor space, floor loading capacity, headroom, economic friction drop of the gases through the reactor, etc., since the number of impacts per unit of time between reacting vapor or gas molecules would hardly be affected by the condition of turbulence attending the flow of the reaction stream through the system.

ACETYLENE GENERATOR

Problem 3—It is required to design a continuous single-pass counter current type vapor-solids reactor of the type shown in Fig. 3, to produce 3 lb. per minute of acetylene with an efficiency of 98 percent with respect to the actual CaC_2 content of the calcium carbide feed. The reaction would be:

$$CaC_2 + 2HOH \longrightarrow Ca(OH)_2 + C_2H_2$$

It is proposed to carry out the reaction in the presence of a 150 percent excess of water vapor entering the reactor at 212 deg. F. and 1 atm. The combined reaction velocity and area constant k_a for the given rate of solids feed has been determined in the laboratory to be 4×10^6. The further conditions of the design are that the reactor may be jacketed to maintain isothermal reaction conditions.

The reactor, shown in Fig. 3, is to operate in the following manner to react finely divided solids with gases or vapors: A rotary bin valve placed between the solids receiver bin and the reactor chamber itself meters a uniform feed of calcium carbide to the suction pipe leading to the eye of a high speed spray wheel. The

† This method of estimating the work of agitation is extremely conservative. Another method which should be used where the power consumption determined as above is inordinately high is as follows: (1) According to the method of Hixson and Baum (*Ind. Eng. Chem.*, **33**, p. 478, 1941; **34**, p. 120, 1942), and others, compute the agitational Reynolds number for the laboratory batch reactor. (2) Assuming the single-pass reactor to be a batch mixing tank of the volume computed by the methods outlined above, solve for the mixing horsepower that will establish an equivalent Reynolds number. (3) Calculate the overall orifice-manifold pressure drop according to the formula $Hp. \times 33{,}000/(Q \times D) =$ over-all orifice-manifold drop in feet. Here $Hp.$ is the power consumption as calculated in Item (2), Q is the throughput rate, cubic feet per min., and D is the average apparent density of the reaction stream.

Fig. 1—Single-pass reaction system for vapor phase oxidation of naphthalene to phthalic anhydride; exchanger-reactor has catalyst in tubes

Fig. 2—Single-pass reactor for hydrogen reduction of nickel oxide, designed to handle the solid in fluidized condition

Fig. 3—Single-pass solids-vapor reactor for making acetylene

Fig. 4—Single-pass pipe-type liquid phase reactor for nickel carbonate

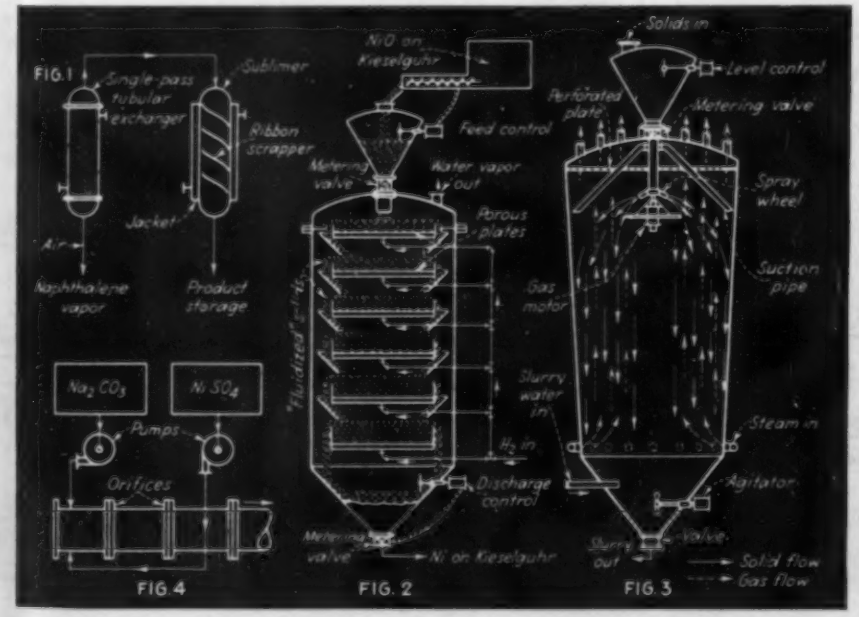


TABLE I

SYSTEM CHARACTERISTIC	ORDER OF REACTION	EXAMPLE	(V_b – R – S) EQUATION	EQUATION NO.
CONSTANT VOLUME INFINITE CONTACT	1ST ORDER	$A \rightarrow B+C+D+E$	$V_b = \frac{R}{k} \ln \frac{a}{a-x}$ $V_b = \frac{R}{k} \ln \frac{N_{Ao}}{N_A}$	1
	2ND ORDER	$2A \rightarrow B+C+D+E$ OR $A+B$ (IN STOICHIOMETRIC BALANCE) $\rightarrow C+D+E$	$V_b = \frac{R}{k} \frac{x}{a(a-x)} = \frac{R^2}{k} \frac{N_{Ao}-N_A}{N_{Ao} N_A}$	2
		$A+B$ (IN EXCESS) $\rightarrow C+D+E$	$V_b = \frac{R \ln \frac{b(a-x)}{a(b-x)}}{k(a-b)} = \frac{R^2}{k} \frac{1}{N_{Ao}-N_{Bo}} \ln \frac{N_{Bo} N_A}{N_{Ao} N_B}$	3
	3RD ORDER	$3A \rightarrow B+C+D+E \ldots$	$V_b = \frac{R}{k} \left[\frac{2x(2a-x)}{a^2(a-x)^2} \right] = \frac{R^3}{k} \left[\frac{2(N_{Ao}-N_A)(N_{Ao}+N_A)}{N_{Ao}^2 N_A^2} \right]$	4
		$2A+B \rightarrow C+B+E \ldots$	$V_b = \frac{R}{k(2b-a)} \left[\frac{2x}{a(a-2x)} + \frac{1}{a-2b} \ln \frac{a(b-x)}{b(a-2x)} \right] =$ $= \frac{R^3}{k(2N_{Bo}-N_{Ao})} \left[\frac{N_{Ao}-N_A}{N_{Ao} N_A} + \frac{1}{N_{Ao}-2N_{Bo}} \ln \frac{N_{Ao} N_B}{N_{Bo} N_A} \right]$	5
		$A+B+C \rightarrow D+E \ldots$	$V_b = \frac{R}{k} \left[\frac{1}{(a-b)(c-a)} \ln \frac{a}{a-x} + \frac{1}{(a-b)(b-c)} \ln \frac{b}{b-x} + \frac{1}{(b-c)(c-a)} \ln \frac{c}{c-x} \right] =$ $= \frac{R^2}{k} \left[\frac{1}{(N_{Bo}-N_{Ao})(N_{Co}-N_{Ao})} \ln \frac{N_{Ao}}{N_A} + \frac{1}{(N_{Ao}-N_{Bo})(N_{Co}-N_{Bo})} \ln \frac{N_{Bo}}{N_B} \right.$ $\left. + \frac{1}{(N_{Bo}-N_{Co})(N_{Ao}-N_{Co})} \ln \frac{N_{Co}}{N_C} \right]$	6
CONSTANT VOLUME FINITE CONTACT	I	LEACHING PROCESS INVOLVING ONE MOL OF LEACHING MATERIAL TO ONE MOL OF SOLID $A_g + B_s \rightarrow C+D$ $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$	$V_b = -\frac{R^2}{(N_{Bo}-N_{Ao})^{2/3} k_3 L} \left[\frac{1}{2} \ln \frac{[(N_{Bo}-N_{Ao})^{1/3} + N_A^{1/3}]^2}{(N_{Bo}-N_{Ao})^{2/3} - (N_{Bo}-N_{Ao})^{1/3} N_A^{1/3} + N_A^{2/3}} \right.$ $\left. + \sqrt{3} \arctan \frac{2N_A^{1/3} - (N_{Bo}-N_{Ao})^{1/3}}{\sqrt{3}(N_{Bo}-N_{Ao})^{1/3}} \right]_{N_A=N_{Ao}}^{N_A=N_A}$	7
		DISSOLUTION PROCESS, A MOLS OF SOLID DISSOLVING IN ANY GIVEN SOLVENT	$V_b = \frac{R^2}{k_3 (N_S-N_{Ao})^{2/3}} \left[\frac{1}{2} \ln \frac{[(N_S-N_{Ao})^{1/3} + N_A^{1/3}]^2}{(N_S-N_{Ao})^{2/3} - (N_S-N_{Ao})^{1/3} N_A^{1/3} + N_A^{2/3}} \right.$ $\left. + \sqrt{3} \arctan \frac{2N_A^{1/3} - (N_S-N_{Ao})^{1/3}}{\sqrt{3}(N_S-N_{Ao})^{1/3}} \right]_{N_A=N_{Ao}}^{N_A=N_A}$	8
		LEACHING PROCESS INVOLVING ONE MOL OF SOLID TO TWO MOLS OF LEACHING MATERIAL $A_g + 2B_s \rightarrow C+D$ $Fe + 2HCl \rightarrow FeCl_2 + H_2$	$V_b = -\frac{R^2}{k_3 a^2} \left[\frac{N_A^{1/3}}{a - 2N_A^{1/3}} + \frac{2r}{3a^2} \left(\frac{1}{2} \ln \frac{(r+N_A^{1/3})^2}{r^2 - rN_A^{1/3} + N_A^{2/3}} \right. \right.$ $\left. \left. + \sqrt{3} \arctan \frac{2N_A^{1/3} - r}{\sqrt{3}\, r} \right) \right]_{N_A=N_{Ao}}^{N_A=N_A}$	9
		SOLID – GAS REACTOR WITH COUNTER CURRENT OPERATION ONLY, IN WHICH ONE MOL OF SOLID AND ONE MOL OF GAS ARE REACTING $A_g + B_s \rightarrow C_g + D_g + E_s$ $FeO + H_2 \rightarrow Fe + H_2O$	$V_b = \frac{k_c N_{Bo} R_0 TA}{k_3 P (N_{Bo}-N_{Ao})^{2/3}} \left[\frac{1}{2} \ln \frac{(N_A^{1/3} - [N_{Bo}+(1-z)N_{Ao}]^{1/3})^2}{N_A^{2/3} + N_A^{1/3}[N_{Bo}+(1-z)N_{Ao}]^{1/3} + [N_{Bo}+(1-z)N_{Ao}]^{2/3}} \right.$ $\left. + \sqrt{3} \arctan \frac{2N_A^{1/3} + [N_{Bo}+(1-z)N_{Ao}]^{1/3}}{\sqrt{3}\,[N_{Bo}+(1-z)N_{Ao}]^{1/3}} \right]_{N_A=N_{Ao}}^{N_A=N_A}$	10
VARIABLE VOLUME, INFINITE CONTACT, GASEOUS OR VAPOR PHASE, UNDER CONSTANT PRESSURE	1ST ORDER	$A_g \rightarrow \alpha B_g + \beta C_g + \rho D_g + \ldots$	$V_s = \frac{R_0 T}{kP} \left[\psi N_{Ao} \ln \frac{N_{Ao}}{N_A} - (\psi - 1)(N_{Ao} - N_A) \right]$	11
	2ND ORDER	$2A_g \rightarrow \alpha B_g + \beta C_g + \rho D_g + \ldots$	$V_s = \frac{R_0^2 T^2}{kP^2} \left[\frac{\psi^2}{4} \frac{(N_{Ao}^2}{N_A} - N_{Ao}) - \psi \left(\frac{\psi}{2} - 1 \right) N_{Ao} \ln \frac{N_{Ao}}{N_A} + \left(\frac{\psi}{2} - 1 \right)^2 (N_{Ao} - N_A) \right]$	12
		$A_g + B_g \rightarrow \alpha C_g + \beta D_g + \rho E_g$	$V_s = \frac{R_0^2 T^2}{kP^2 (N_{Bo}-N_{Ao})} \left[-\left[N_{Bo} + (\psi-1)N_{Ao} \right]^2 \ln \left(\frac{N_{Bo}}{N_{Bo}-N_{Ao}+N_A} \right) \right.$ $+ \left[N_{Bo} + (\psi-1)N_{Ao} \right] \ln \frac{N_{Ao}}{N_A} - 2(\psi-2) \left[N_{Ao} + (\psi-1)N_{Ao} \right] (N_{Ao} - N_{Ao}) \rho$ $- (\psi-2)^2 \left\{ \frac{[N_{Ao}^2 - (N_{Bo}-N_{Ao}+N_A)^2}{2} - 2(N_{Bo}-N_A)(N_A - N_{Ao}) \right.$ $\left. \left. + (N_{Bo}-N_{Ao})^2 \ln \frac{N_{Bo}}{N_{Bo}-N_{Ao}+N_A} \right\} + \left(\frac{\psi-2}{\rho/2} \right)^2 (N_{Ao}^2 - N_A^2) \right]$	13
	3RD ORDER	SOLIDS – GAS REACTOR WITH COUNTER CURRENT OPERATION ONLY, IN WHICH ONE MOL OF GAS AND ONE MOL OF SOLID ARE REACTING $A_g + B_s \rightarrow \alpha C_g + \beta D_g + \rho E_g + F_g + G_s$	$V_s = \frac{R_0^3 T^2}{k_3 P^2} \left\{ w^2 - 2gwd + 3gd^2 \left[\frac{1}{2} \ln \frac{(N_A^{1/3} - g^{1/3})^2 (N_{Ao}^{2/3} + N_{Ao}^{1/3} g^{1/3} + g^{2/3})}{(N_A^{1/3} + N_A^{1/3} g^{1/3} + g^{2/3})(N_{Ao}^{1/3} - g^{1/3})^3} \right.^{N_A=N_A}_{N_A=N_{Ao}} \right.$ $- \sqrt{3} \arctan \frac{2N_{Ao}^{1/3} + g^{1/3}}{\sqrt{3} g^{1/3}} + \sqrt{3} \arctan \frac{2N_{Ao}^{1/3} + g^{1/3}}{\sqrt{3} g^{1/3}} \left. \left. - 6wd(N_A^{1/3} - N_{Ao}^{1/3}) + 3d^2 (g N_A^{1/3} - g N_{Ao}^{1/3}) + \frac{N_A - N_{Ao}}{4} \right] \right\}$	14
			$h = \frac{k_3 R T}{k_2 P} \left[3d (N_A^{1/3} - N_{Ao}^{1/3}) - \frac{w - dg}{g^{1/3}} \left[\sqrt{3} \arctan \frac{2N_A^{1/3} + g^{1/3}}{\sqrt{3} g^{1/3}} \right.^{N_A=N_A}_{N_A=N_{Ao}} \right.$ $\left. \left. \sqrt{3} \arctan \frac{2N_{Ao}^{1/3} + g^{1/3}}{\sqrt{3} g^{1/3}} - \frac{1}{2} \ln \frac{(N_A^{1/3} g^{1/3})(N_{Ao}^{2/3} + N_{Ao}^{1/3} g^{1/3} + g^{2/3})}{(N_{Ao}^{1/3} N_A^{2/3} + g^{2/3})(N_{Ao}^{1/3} g^{1/3})^2} \right] \right]$	15
		SOLIDS – GAS REACTOR WITH COUNTER CURRENT OPERATION ONLY, IN WHICH ONE MOL OF SOLID REACTS WITH 2 MOLS OF GAS $A_g + 2B_g \rightarrow \alpha C_g + \beta D_g + \rho E_g + F_g + G_s$	$V_s = -\frac{R_0^3 T^2}{k_2 P^2} \left[\frac{7 f^3 N_A^{1/3}}{16} + \frac{7 u f^2 N_A^{2/3}}{8} - 3 v f^2 N_A^{1/3} \right.$ $+ \frac{1}{3.56 u^{1/3}} \left(\frac{2v^2}{u} + \frac{3\sqrt{2} f}{2} - 3 u f^2 + \frac{7 u^2 f^3}{8} \right) \left(\frac{1}{2} \ln \frac{N_A^{1/3} - (\frac{f}{2})^{1/3}}{N_A^{1/3} + N_A^{1/3} (\frac{f}{2})^{1/3} + (\frac{f}{2})^{2/3}} \right.^{N_A=N_A}_{N_A=N_{Ao}}$ $\left. \left. \sqrt{3} \arctan \frac{2N_A^{1/3} + (\frac{f}{2})^{1/3}}{\sqrt{3}(\frac{f}{2})^{1/3}} \right) - \frac{2\sqrt{2} v^2 + 3 v f + u N_A^{1/3} - 3 u f^2 + \frac{7}{8} u^2 f^3 - f^2 N_A^{1/3}}{2u(u - 2N_A)} \right]_{N_A=N_{Ao}}^{N_A=N_A}$	16
			$h = \frac{k_2 R_0^2 T^2}{k_3 P^2} \left[\frac{3f^2}{8} (2u + N_A) N_A^{1/3} - \frac{4u^2 N_A^{2/3} - 4uvf N_A^{1/3} + u^2 f^2 N_A^{1/3}}{4u(u - 2N_A)} \right.$ $+ \frac{4v^3 + 2uvf + u^2 f^2}{7.56 u^{1/3}} \left\{ \frac{1}{2} \ln \frac{[N_A^{1/3} - (\frac{f}{2})^{1/3}]^2}{N_A^{2/3} + N_A^{1/3} (\frac{f}{2})^{1/3} + (\frac{f}{2})^{2/3}} \right.^{N_A=N_A}_{N_A=N_{Ao}}$ $\left. \left. \left. - \sqrt{3} \arctan \frac{2N_A^{1/3} + (\frac{f}{2})^{1/3}}{\sqrt{3}(\frac{f}{2})^{1/3}} \right\} \right]$	17

TABLE II

SYSTEM CHARACTERISTIC	ORDER OF REACTION	EXAMPLE	(V_s–R–S) EQUATION FOR SINGLE MULTI-PASS REACTOR	(V_s–R–S) EQUATION FOR m IDENTICAL REACTORS IN SERIES	EQUATION NO.
CONSTANT VOLUME INFINITE CONTACT	1ST ORDER AND PSEUDO-MONOMOLECULAR REACTIONS	$A \rightarrow B+C+D+E$ ANY MULTI-MOLECULAR REACTION IN WHICH ALL BUT ONE OF THE REACTANTS IS PRESENT IN GREAT EXCESS BEYOND STOICHIOMETRIC REQUIREMENTS	$\left(\frac{a-x}{a} \right) = \left(\frac{p}{e^{ktm-q}} \right)^m$	$\left(\frac{a-x}{a} \right) = \left(\frac{p}{e^{ktm-q}} \right)^m$ NOTE: THE QUANTITY $\left(\frac{a-x}{a} \right)$ IS EVALUATED IN THE CASE OF PSEUDO-MONOMOLECULAR REACTIONS IN TERMS OF THE REACTANT WHICH IS NOT PRESENT TO EXCESS	18
	2ND ORDER	$2A \rightarrow B+C+D+E$ OR $A+B$ (IN STOICHIOMETRIC BALANCE) $\rightarrow C+D+E$	$t_m = \frac{\frac{R}{a} x}{k(a - \frac{a-R}{a} x)(a-x)}$	* $t_m = \frac{\frac{R}{a}}{k\left[a - \frac{a-R}{a}(x_m - x_{m-1})\right](a-x_m)}$	19
		$A+B$ (IN EXCESS) $\rightarrow C+D+E$	$t_m = \frac{\ln \frac{(b - \frac{a-R}{a} x)(a-x)}{(a - \frac{a-R}{a} x)(b-x)}}{k(a-b)}$	* $t_m = \frac{\ln \left[\frac{b - x_m + \frac{a-R}{a}(x_m - x_{m-1})}{a - x_m + \frac{a-R}{a}(x_m - x_{m-1})} \right] \frac{1}{(b-x_m)}}{k(a-b)}$	20
	3RD ORDER	$3A \rightarrow B+C+D+E$	$t_m = \frac{2\frac{R}{a} x \left[2(a-x) + \frac{a-R}{a} x \right]}{k(a - \frac{a-R}{a} x)^2 (a-x)}$	* $t_m = \frac{2\frac{R}{a} \left[(b-x_m - x_{m-1}) \sqrt{(a-x_m + \frac{a-R}{a}(x_m - x_{m-1}))^3} \right]}{k\left[a - x_m + \frac{a-R}{a}(x_m - x_{m-1}) \right]^{3/2} (a-x_m)}$	21
		$2A+B \rightarrow C+D+E$	$t_m = \frac{1}{k(2b-a)} \left[\frac{2\frac{R}{a} x}{(a - 2\frac{a-R}{a} x)(a-2x)} \right.$ $\left. + \frac{1}{a-2b} \ln \frac{(a - 2\frac{a-R}{a} x)(b-x)}{(b - \frac{a-R}{a} x)(a-x)} \right]$	* $t_m = \frac{1}{k(2b-a)} \left[\frac{2\frac{R}{a} (x_m - x_{m-1})}{\sqrt{(a - 2x_m + 2\frac{a-R}{a}(x_m - x_{m-1}))^3 (b - x_m + \frac{a-R}{a}(x_m - x_{m-1}))}} \right.$ $\left. + \frac{1}{a-2b} \ln \left[\frac{(a - 2x_m + 2\frac{a-R}{a}(x_m - x_{m-1}))^3 (b - x_m + \frac{a-R}{a}(x_m - x_{m-1}))}{(a - 2x_m)^3 (b - x_m)} \right] \right]$	22
		$A+B+C \rightarrow D+E$	$t_m = \frac{1}{k} \left[\frac{1}{(a-b)(c-a)} \ln \frac{a - \frac{a-R}{a} x}{a-x} \right.$ $+ \frac{1}{(a-b)(b-c)} \ln \frac{b - \frac{a-R}{a} x}{b-x}$ $\left. + \frac{1}{(b-c)(c-a)} \ln \frac{c - \frac{a-R}{a} x}{c-x} \right]$	* $t_m = \frac{1}{k} \left[\frac{1}{(a-b)(c-a)} \ln \frac{a - x_m + \frac{a-R}{a}(x_m - x_{m-1})}{a - x_m} \right.$ $+ \frac{1}{(a-b)(b-c)} \ln \frac{b - x_m + \frac{a-R}{a}(x_m - x_{m-1})}{b - x_m}$ $\left. + \frac{1}{(b-c)(c-a)} \ln \frac{c - x_m + \frac{a-R}{a}(x_m - x_{m-1})}{c - x_m} \right]$	23

* FOR m IDENTICAL VESSELS IN SERIES USE A STEPWISE APPLICATION OF THE EQUATION GIVEN HERE

SYSTEM CHARACTERISTIC					EQUATION NO.
CONSTANT VOLUME FINITE CONTACT		DISSOLUTION PROCESS	SEE NEXT COLUMN	$m = \frac{-\frac{V_s}{k R_0 N_{Ao}} \left[\sqrt{3} \arctan \frac{2N_A^{1/3} - (N_S - N_{Ao})^{1/3}}{\sqrt{3}(N_S - N_{Ao})^{1/3}} \right]_{N_A=N_{Ao}}^{N_A=N_A}}{t_m}$ $+ \frac{\ln \frac{[(N_S - N_{Ao})^{1/3} + N_A^{1/3}]^2}{(N_S - N_{Ao})^{2/3} - (N_S - N_{Ao})^{1/3} N_A^{1/3} + N_A^{2/3}} \Big]_{N_A=N_{Ao}}^{N_A=N_A}}{t_m}$	24
		LEACHING PROCESS INVOLVING ONE MOL OF LEACHING MATERIAL TO ONE MOL OF SOLID	SEE NEXT COLUMN	$m = \frac{-\frac{V_s}{k R_0 N_{Ao}} \left[\sqrt{3} \arctan \frac{2N_A^{1/3} - (N_{Bo} - N_{Ao})^{1/3}}{\sqrt{3}(N_{Bo} - N_{Ao})^{1/3}} \right]_{N_A=N_{Ao}}^{N_A=N_A}}{t_m}$ $+ \frac{\frac{1}{2} \ln \frac{[(N_{Bo} - N_{Ao})^{1/3} + N_A^{1/3}]^2}{(N_{Bo} - N_{Ao})^{2/3} - (N_{Bo} - N_{Ao})^{1/3} N_A^{1/3} + N_A^{2/3}} \Big]_{N_A=N_{Ao}}^{N_A=N_A}}{t_m}$	25
		LEACHING PROCESS INVOLVING ONE MOL OF SOLID TO TWO MOLS OF LEACHING MATERIAL	SEE NEXT COLUMN	$m = \frac{-\frac{V_s^2}{k R_0^2} \left[\frac{2c}{\sqrt{3}a^2} \left[\frac{1}{2} \ln \frac{(r + N_A^{1/3})^2}{r^2 - rN_A^{1/3} + N_A^{2/3}} \right.^{N_A=N_A}_{N_A=N_{Ao}} \right.}{t_m}$ $+ \frac{\left. \sqrt{3} \arctan \frac{2N_A^{1/3} - r}{\sqrt{3}\, r} \right]_{N_A=N_{Ao}}^{N_A=N_A}}{t_m}$	26

TABLE III

SYSTEM CHARACTERISTIC	ORDER OF REACTION	EXAMPLE	(V_s – R – S) EQUATION	EQUATION NO.
CONSTANT VOLUME INFINITE CONTACT	2ND ORDER	$2A \rightarrow B+C+D+E$ OR $A+B$ (IN STOICHIOMETRIC BALANCE) $\rightarrow C+D+E$	$e^{-\left[\frac{a(b-x)}{b(a-x)} \right]} = \left(\frac{p}{e^{ktm} - q} \right)^m$	27
		$A+B$ (IN EXCESS) $\rightarrow C+D+E$	$\left[\frac{a(b-x)}{b(a-x)} \right] = \left(\frac{p}{e^{ktm(a-b)} - q} \right)^m$	28
	3RD ORDER	$3A \rightarrow B+C+D+E$	$e^{-\left[\frac{2x(2a-x)}{a^2(a-x)^2} \right]} = \left(\frac{p}{e^{ktm} - q} \right)^m$	29
		$2A+B \rightarrow C+D+E$	$e^{-\left[\frac{2x}{a(a-2x)} + \frac{1}{2a-b} \ln \frac{a(b-x)}{b(a-2x)} \right]} = \left(\frac{p}{e^{ktm} - q} \right)^m$	30
		$A+B+C \rightarrow D+E$	$\left(\frac{a-x}{a} \right)^{\frac{1}{(a-b)(c-a)}} \left(\frac{b-x}{b} \right)^{\frac{1}{(b-c)(a-b)}} \left(\frac{c-x}{c} \right)^{\frac{1}{(c-a)(b-c)}} = \left(\frac{p}{e^{ktm} - q} \right)^m$	31

NOTE IN TABLE III: WHERE A HIGH DEGREE OF REACTION COMPLETION IS REQUIRED AND WHERE "INSTANTANEOUS DILUTION" OF THE INFLUENT STREAM OCCURS, THE VALUE OF R OBTAINED IN THESE EQUATIONS SHOULD BE REDUCED TO 75 TO 80 PERCENT OF THE COMPUTED VALUES

TABLE IV

SYSTEM CHARACTERISTIC	ORDER OF REACTION	$R_{m,s}$ EQUATION	EQUATION NO.
ANY	ANY	$R_{m,s} = \frac{p^m}{(m-1)!} \left[\frac{[(m+s)!}{(s+1)!} \frac{q^{s+1}}{(p)} + \frac{(m-1)(m+s)!}{(s+2)!} \frac{q^{s+2}}{(p^2)} + \frac{(m-1)(m-2)(m+s)!}{(s+3)!} \frac{q^{s+3}}{(p^3)} \right.$ $\left. + \frac{(m-1)(m-2)(m-3)(m+s)!}{(s+4)!} \frac{q^{s+4}}{(p^4)} + \ldots + \frac{(m-1)!}{p^m} \frac{q^{m+s}}{} \right]$	32

NOMENCLATURE

a	Starting concentration of the reactant A
a'	$(N_{B_0} - 2N_{A_0})$
b	Starting concentration of the reactant B
c	Starting concentration of the reactant C
d	$(1 + \psi)$
e	Base of natural logarithms
f	$2(1 + \psi/2)$
g	$N_{B_0} + (1 - x + \psi)N_{A_0}$
h	Height of a countercurrent gas-solids reactor
k	Reaction velocity constant
k_s	Product of k and the factor $(k_\rho^{1/3}g^{1/3}/\omega^{2/3})$
k_f	Stokes law rate of fall
k_0	Number of particles of uniform diameter
ln	Logarithm to the base e
m	Number of vessels in series
n_a	Number of turbine agitators
p	Ratio of R to Q in a continuous multi-pass mixer or reactor
q	$(1 - p)$
r	$-\frac{1}{2}(N_{B_0} - 2N_{A_0})$
s	Any integer (1, 2, 3, ...n)
t_m	Time for one pass from inlet to outlet in a multi-pass reactor (i.e., V_R/Q in draft-tube type such as Fig. 6)
u	$N_{B_0} + 2(1 - x)\,N_{A_0}$
v	$N_{B_0} + 2(1 - x + \frac{1}{2}\psi)N_{A_0}$
w	$N_{B_0} + (1 - x)N_{A_0}$
x	Instantaneous depletion in concentration of a reactant
z	Final extent of reaction of a solid
A	Area of countercurrent gas-solids reactor
N_A, N_B, N_C	Residual number of mols of reactant or solute A, B, or C after "contact time" t
N_{A_0}, N_{B_0}, N_{C_0}	Feed stream of reactant or solute A, B, or C in mols per unit of time
N_s	Number of mols of solute at saturation in feed stream
P	Absolute pressure
Q	Rate of turnover (circulation) effected by circulation element of multi-pass reactor, etc.
R	Rate of throughput, volume per unit time, through a continuous system
R_g	Gas constant
$R_{m,s}$	Proportion of feed stream remaining in m vessels for time equal or more than $m + s$ passes
S	Completion of reaction, etc.
T	Absolute temperature
V_s	Required equipment volume
V_R	Working volume of each unit of a continuous multi-pass series
α, β, ϕ	Coefficients of gaseous or vapor products of a reaction
ψ	Sum of the coefficients of all gaseous products of a reaction
ρ	$\ln N_{B_0}/(N_{B_0} - N_{A_0} + N_A)$
ω	Absolute density of solids particles

spray wheel scatters the feed across the breadth of the reactor chamber. To improve the distribution a portion of the effluent gases is drawn through suction pipes to the solids duct, the solids being "emulsified" in this gas in passing to the eye of the spray wheel and through the spray wheel.

The scattered solids settle to the bottom of the chamber against a rising stream of acetylene and water vapor. This method achieves counter-current contact between the falling solids and an atmosphere which is progressively richer in the water vapor reactant. The reacted solids settle into the conical portion of the reactor chamber where they are continuously slurried in water for continuous removal from the chamber.

It is necessary to determine the height and diameter of such a reactor for the acetylene capacity mentioned. The production of 3 lb. per minute of acetylene involves 0.1153 lb.-mols per minute. This would require $(64/26) \times 0.1153 \div 0.98 = 0.290$ lb.-mol $CaC_2 = N_{A_0}$, where 98 percent efficiency of reaction is established. Here 64 is taken to be the molecular weight of the calcium carbide and 26 the molecular weight of acetylene.

A 150 percent excess of water vapor reactant means a flow of 0.3995 lb.-mols of steam per minute. It will be seen that only 1 mol of gas is produced in the reaction. From the above, we may write: $N_{A_0} = 0.290$; $N_A = 0.0058$; $N_{B_0} = 0.3995$; $x = 0.98$; $\psi = 1.0$; $k_s = 4 \times 10^5$; $k_f = 4.43$; $T = 672$ deg. F. abs.; $R_g = 0.729$; $P = 1.0$; $f = 2(1 + \frac{1}{2}\psi) = 3$; $v = 0.7015$; $u = 0.4111$; $N_{A_0}^{1/3} = 0.662$; and $N_A^{1/3} = 0.179$.

Substituting these quantities in Equation (16) we find that the required V_s would be 4,920 cu. ft.

In order to set an "immersion time" for the solids feed in the vapor channel which is consistent with a 98 percent conversion of the calcium carbide, it is then necessary that we determine the required height of the reaction chamber. This involves first the calculation of the Stokes law settling velocity of the solids particles. The computed value of k_f is 4.43 ft. per min., where the absolute density is taken at 2.2 g. per cu. cm., the viscosity of the fluid is 0.00122 poises, and the particle diameter is 0.25 mm. It is computed on the basis of falling in a still atmosphere. After the height and the volume of the chamber are determined according to Equations (16) and (17) it is then necessary to calculate the maximum vapor drift velocity at any point in the column, so as to ascertain the extent to which the normal Stokes law settling rate is disturbed. By Equation (17) h is found to be 12 ft.

It follows, from the above values of V_s and h, that the area of the chamber would be 410 sq. ft. (its diameter being 22.85 ft.). From the chemical equation and the quantity of excess water used, it can be seen that the maximum vapor velocity would be established at the point of water vapor feed to the chamber. At this point, the vapor velocity would be $0.3995 \times 18 \times 26.8 \div 4.10 = 0.47$ ft. per min. This velocity is of such a low order that no appreciable interference with the computed Stokes law rate of settling should be expected.

Finally, it should be noted that one other condition of the derivation of Equations (16) and (17) is that the solids particles are considered to react in progressively concentric receding layers, the particles themselves suffering no appreciable change in diameter. Where the condition of a constant particle diameter does not hold, it is permissible to substitute in the Stokes law equation the log mean diameter between the initial and the final sizes of particles. The condition of the application of the Stokes law equation in determining the settling velocity is that the settling particles, in their various stages of reaction, suffer no appreciable change in absolute density. Where this condition does not actually obtain, it is permissible to work with the log mean of the initial and final densities.

MULTI-PASS REACTORS

Tables II, III and IV contain equations which we use in relating throughput, extent of reaction completion, and system volume in the design of multi-pass continuous reactor and mixer problems.

We have confined the equations listed to the most commonly encountered instances of continuous reactor and mixer design. Thus, it will be noted, we have dealt only with constant volume systems. A more complicated set of expressions is involved in the use of systems which show a variable volume characteristic. However, it is worth noting that the use of multi-pass type reactors is confined principally to the handling of liquid-phase systems, and liquid-phase systems very infrequently show sharp variable volume characteristics. It will also be observed that we have listed two different sets of equations for attacking the design problems of second and higher order reactions. The equations listed in Table II for such reactions are based upon an instantaneous dilution of the influent to each vessel by the existing contents of the vessel.

The equations listed in Table III for second and higher order reactions do not assume instantaneous dilution of the influent stream to each reactor by the existing contents of the reactor. In the handling of second and higher order reactions the equations in Table III may be used to determine broadly the throughput vs. completion relationships which hold for any given number of identical multi-pass vessels in series, provided: (1) The fluid characteristics of the reaction stream are such that poor mixing would be obtained; or (2) the ratio of throughput to the circulating capacity of the mixer element is so high that a comparatively limited amount of blending of the influent stream with the existing contents of the vessel takes place.

The equations for second and higher order reactions shown in Table II should be employed wherever the assumption can be made that instantaneous or near-instantaneous dilution of the incoming stream with the existing contents of the vessel occurs for all practical purposes. In any case, the equations appearing in Table III may be used to approximate the throughput capacity which would be established when instantaneous dilution of the influent stream is a valid assumption. That is to say, it is possible to determine R by the use of the equations in Table III, then correct

R according to the note at the bottom of Table III for use in systems where instantaneous dilution may be assumed, finally checking this figure for throughput by the step-wise or single-vessel equations for second and higher order reactions which appear in Table II.

We have also included in the illustrative problems given below several problems illustrating the computations of purging time, transiency time and the design of continuous mixing equipment on the principle of "retention time" only (See Problems 6, 7, and 8.)

Problem 4—One method for production of the highly important amino acid β-alanine is by the action of sodium hypobromide on succinimide. The succinimide, in turn, can be made by prolonged heating of succinamide, with the release of ammonia. This latter reaction may be shown as:

$$(CH_2CONH_2)_2 \longrightarrow (CH_2CO)_2NH + NH_3$$

It may be treated as a unimolecular reaction for design purposes.

Assume that it is desired to produce succinimide by this method. Two reactors of the type shown in Fig. 6 are available, each with a working capacity of 100 gal. Each unit is equipped with a top entering dual-turbine mixing assembly, consisting of two 9-in. diameter turbines, rotating with a peripheral speed of 1,000 ft. per min. One of the turbines is located just below the draft tube, very close to the bottom of the vessel, the other 27 in. above the first. If a reaction yield of 80 percent is necessary to make the process economically feasible, what will be the daily capacity of the plant, with the two units hooked up in series?

Since this reaction may be treated as a first order type, the reaction velocity equation (Equation 1) may be given as $tk_1 = \ln a/(a-x)$. The first step is to run a batch reaction in the laboratory to determine k. This, of course, must be done under conditions of agitation and temperature similar to those to be used in the plant. In each of the units described above, approximately ½ hp. would be developed, providing very rapid agitation. If a 1-gal. reactor were to be used for the batch run, about 1/30 hp. input would be necessary.

Assume that in the batch test, a 75 percent conversion of the succinamide can be accomplished in 3 hr. of reaction. Then $tk_1 = \ln 1/(1-0.75) = 0.602$ and $k_1 = 0.602/180 = 0.00772$ per min.

DESIGNING THE REACTOR

The working design for the continuous reactor is given by Equation (18). Although this equation was derived without considering the effect, on the reaction kinetics, of the dilution of the incoming stream by the recycle streams, its use in this case will be entirely correct, since concentration has no bearing in a unimolecular reaction.

The circulating rate of a 9-in. diameter turbine, with a tip speed of 1,000 ft. per min., assuming a solution density of 1.2, would be 55 cu.ft. per min. Using the efficiency of circulation of 0.85, which is typical for turbine mixers, we have $Q = 0.85 \times 55 \times 7.5$ gal. per cu.ft. $= 350$ g.p.m., and $V_s = 100$ gal.. The smallest length of time which a particle can spend in one of the vessels will be $t_m = V/Q = 100/350 = 0.285714$, so $k_1 t_m = 0.00772 \times 0.285714 = 0.002206$; $m = 2$; and $p = R/Q = R/350$. Solving Equation (18) for R we find $R = 0.613$ g.p.m. With a specific gravity of 1.2, this would represent a daily capacity of $0.613 \times 1.2 \times 8.35 \times 24 \times 60 = 8{,}820$ lb. per day.

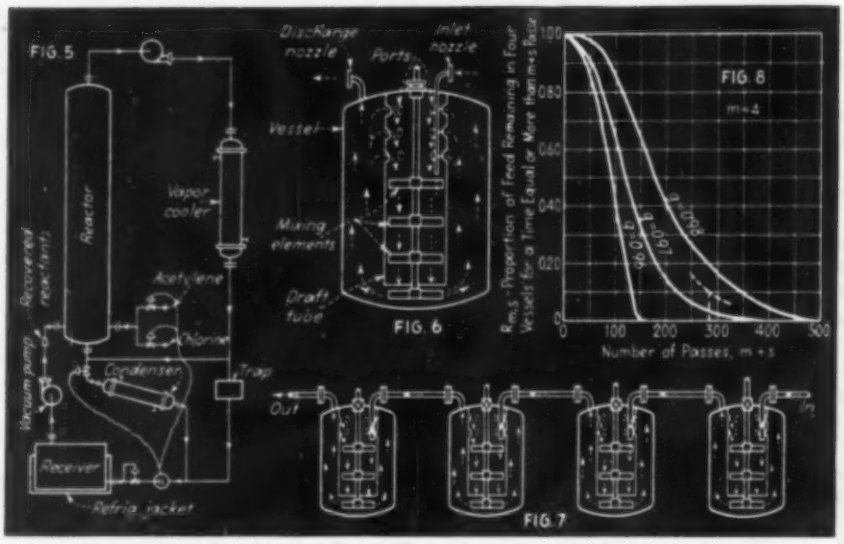


Fig. 5—Multi-pass reactor for highly exothermic reactions such as vapor phase chlorination of acetylene to acetylene tetrachloride; cooled recycled material provides heat capacity to absorb reaction heat

Fig. 6—Draft tube reactor with channelized internal recirculation

Fig. 7—Series of four draft tube reactors

Fig. 8—Proportion of feed remaining in four vessels in series for time equal to or longer than $m + s$ passes

Problem 5—A chemical plant contains four identical reaction vessels operating batchwise to carry out the reaction: $A + B \rightarrow C + D$. This reaction follows the normal curve for a second order reaction. In the process as run, the initial concentration of A is 10 mols per liter and that of B is 8 mols per liter. The reaction time is 3 hr., and a yield of 75 percent is obtained, based upon component B (i.e., 6 mols of the 8 introduced is reacted.)

Each vessel has a diameter of 4 ft. and a straight side height of 6 ft. The maximum working capacity V_s of each vessel is 610 gal. Each is equipped with a top-entering dual-propeller mixing assembly, consisting of two 8-in. diameter × 14.5-in. mean pitch three-bladed marine propellers, rotating at 1,125 r.p.m.

What would be the capacity of the plant, if the reactors were operated on a continuous basis, with the same reaction yield: (1) If the four units were hooked in series as in Fig. 7; (2) if two units of two vessels in the series were employed?

The general integrated equation for a reaction of this type (Equation 3) may be expressed as $t(a-b)k_2 = \ln[b(a-x)/a(b-x)]$ from which k_2 for this reaction is calculated as $\ln[8(10-6)/10(8-6)] \div 180(10-8) = 0.001308$ liter/(mol min.)

Now, in the case of this reaction, since we shall assume that the fluid characteristics of the reaction stream are such as to warrant the assumption of near-complete instantaneous dilution of the influent to each vessel by the existing contents of that vessel, the use of Equation (20) is indicated. Here x_m and x_{m-1} represent the depletion of a or b in the streams emerging from the mth and $m-1$th reactor in series, respectively. The terms t_m, Q, R, k, a, and b are as previously defined.

For the reactors on hand, the theoretical circulating capacity Q of the propeller mixer is (from the nomograph in Chem. & Met., Aug. 1943, p. 109) 475 cu.ft. per minute. However, the actual rate for propeller mixers is normally about 60 percent of the theoretical, so that Q would be $0.6 \times 475 = 285$ c.f.m. $= 2{,}130$ g.p.m. Since the volume V_s of each vessel is 610 gal., $t_m = V_s/Q = 610/2.130 = 0.2865$ min. Since we desire a 75 percent depletion of component B, then for the case of four vessels in series, we wish: x_m (which is x_4) to equal 6 mols per liter. It is obvious that the effluent from the third, second and first reactors will each contain, respectively, an increasing amount of component B, or a smaller depletion x. It will also be seen that x_0, which is equivalent to the input to the first reactor, will be zero. The solution therefore becomes one of trial and error. A value of R must first be assumed. Then, using $x_4 = 6$, calculate the value of x_3, then x_2, x_1 and x_0. If x_0 is greater than zero it means that the assumed throughput rate is too high. If x_0 is less than zero, the assumed rate is too low. That value of R which will give a value of x_0 substantially equal to zero, with $x_4 = 6$, will be the allowable rate of throughput for the system.

Applying Equation (28) of Table III to the problem (to establish the probable throughput capacity through the four vessels in series) we find that $S = 10(8-6)/8(10-$

$6) = [p/(e^{0.0007402} + p - 1)]^4$ from which p is found to equal 0.00567. Therefore $R = pQ = 0.00567 \times 2{,}130 = 12.1$ g.p.m. If we then correct R as determined above for the condition of "instantaneous dilution" of the influent to each vessel in accordance with the note at the bottom of Table III, we find that the corrected throughput rate R would be $0.8 \times 12.1 = 9.68$ g.p.m.

We therefore first assume a value of $R = 9.68$ in applying the corresponding step-wise equation (Equation 20) found in Table II, from which x_s is found to be 5.4. Then proceeding step-wise, we find $x_3 = 4.5$, $x_1 = 3.04$ and $x_0 = 0.2$. Since x_0 is so close to zero, it means that our first assumption for R is very nearly correct. By further attempts, the proper value of R is found to be about 9.5 g.p.m.

If instead we were to use two units, each with two vessels in series, the procedure would be as follows: Consider each two-vessel system separately, and determine the allowable throughput. In this case, $x_m = x_1 = 6$. We need only solve for x_1 and x_0. The capacity of the plant would then be twice this figure. It would be found that the plant capacity would be slightly less for the case of two parallel units of two vessels, than it would be for one unit of four vessels. In the latter case, the mean deviation from the calculated mean detention time would be less, which is often quite important in some processes.

Problem 6—In acidulating the chlorinated liquor in the manufacture of chloral by the chlorination of 95 percent ethanol, it is found that the chlorinated liquor must be refluxed "above" 96 percent sulphuric acid for a period of 1 hr. It has been considered consistent with the economics of the operation that in a plant producing roughly 93,000 lb. per month of chloral, not more than 5 percent of the incoming chlorinated liquor should pass from the continuous acidulator in less than 1 hr.

The acidulating tank consists of a 500-gal. working capacity vessel equipped with a draft tube and turbine mixer assembly. The turbine causes a turnover rate of 1,348 g.p.m. The feed and discharge nozzles are so located that for all practical purposes $t_m = V/Q$, or 0.371 min. If the combined flow of 96 percent acid and chlorinated liquor is 0.322 g.p.m., is the mentioned tank acceptable?

Let $R_{m,s}$ be that portion of the influent stream which spends a time equal to or greater than $(m + s)$ passes in a system consisting of m vessels in series. A stay of 1 hr. in one vessel ($m = 1$) implies that $60/0.371 = m + s$ passes and $s =$ approximately 161 passes. The value of $p = 3.22/1{,}348 = 0.000239$, whereby q is equal to 0.999761. Substituting these values in Equation (32) for $R_{m,s}$, using only the first term in the brackets (for one vessel), we find that $R_{m,s} = (0.999761)^{180} = 0.967$, which means that 96.7 percent remains 1 hr. or more. Therefore the proposed acidulating tank would be satisfactory.

PURGING A SYSTEM

Problem 7—A plant contains a continuous reactor system consisting of four 1,000 gal. working capacity multi-pass reactors in series. The system has become contaminated and it is now necessary to determine how long, under the normal conditions of throughput, it would take to return the system to normal operation by purging the existing contents of the system with a continued feed of new reactants. It is assumed that substantially normal operation will be regained when 90 percent of the contaminating component has been removed.

The circulating capacity of the mixer in each reactor tank is given as 2,000 g.p.m., the feed rate to the system is 50 g.p.m., and the minimum time required for one pass is 0.5 min. It will readily be seen that the "displacement" of the contaminated material by the feed stream is accomplished by mixing the feed stream with the existing contents of the vessel, and conveying the contaminated material in the "displacement stream."

It can be shown that the purging time may be calculated by setting $R_{m,s}$ equal to 10 percent. Using $R_{m,s}$ as defined in Problem (6), and substituting the values 0.98, 0.97 and 0.96 for q, the family of curves of Fig. 8 has been constructed for a series of four vessels ($m = 4$), in which the proportion of feed remaining in the system for a time equal to or more than the time for $m + s$ passes has been plotted against values of $m + s$. Interpolating in Fig. 8 between the curves for $q = 0.98$ and $q = 0.97$ for the value of $q = 1 - 50/2{,}000 = 0.975$ it will be seen that only 10 percent of the effluent stream will consist of contaminated material after 280 passes. This would mean that 280×0.5 min. per pass $= 140$ min. must elapse, and that $0.5 \times 280 \times 50$ g.p.m. $= 7{,}000$ gal. of feed would be required to obtain the desired amount of purging.

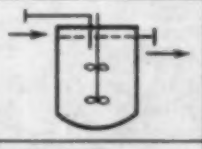
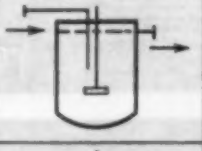
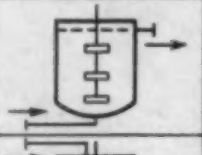
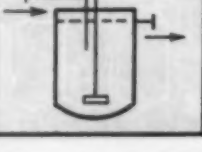
Problem 8—Let us assume the reaction system of the previous example, i.e., four reactors in series. The capacity of each reactor is 1,000 gal., the circulation rate of the agitator is 2,000 gal. per minute, and the throughput rate is 50 g.p.m. Now, in running the reaction batchwise, it is found that after 1½ hr. time there is practically no further reaction. How long will it take the system to reach virtual steady-state conditions after the time of start-up, if the system has been started by loading all of the reactors and operating them batchwise for the period of 1½ hr. previous to beginning the continuous feed of reactants?

It is quite apparent that once continuous feeding of the new stream of reactants is established, all of the batchwise operation contents of the system will spend 1½ hr. or more in the system. In order that steady-state operation may be approximated, it will be seen that the proportion of the batchwise contents of the vessel present in the effluent is reduced to that amount which, under steady-state conditions, has remained 1½ hr. or more. The proportion of material under steady-state conditions which would remain in the system for 1½ hr. or more would be that remaining for $(1.5 \text{ hr.} \times 60)/0.5$ min. per pass $= 180$ passes, or $R_{4,\,180}$. But the amount of time required to purge the batchwise contents of the system to a proportion of the effluent equal to $R_{4,\,180}$ would be 180 passes. This means the transiency time would equal 1½ hr. after continuous feeding of the reactants had begun.

It was mentioned earlier in this article that the equations given here for multi-pass systems are based on the use of equipment which employs a draft tube to channelize the internal flow. With certain small changes in some of the equations, as indicated in Fig. 9, types of equipment sketched in the left hand portion of this diagram can also be treated.

Fig 9—Methods for evaluating t_m and right hand sides of Equations 18, 27, 28, 29, 30 and 31 for vessels in which flow is not channelized by draft tube

Note: Factor A here equals the right hand sides of Equations 18, 27, 28, 29, 30 and 31, where λ is the exponent of e in each equation. In Equations 19 to 25 incl., t_m for non-channelized flow equals Vs/Q

Vessel Construction		t_m	Factor A
Single or multiple propellor assembly		$\frac{V_E}{Q}$	As in Tables II and III
One double-suction turbine (approx. centrally placed)		$\frac{V_E}{Q}$	$e^{-(m-1\frac{1}{2})\lambda}\left(\frac{pe^{\lambda}}{e^{\lambda}-q}\right)^{m}$
n_0 double-suction turbines dividing tank vol. equally		$\frac{V_E}{n_0 Q}$	$e^{-(m-1\frac{1}{2})\lambda}\left(\frac{pe^{\lambda}}{e^{\lambda}-q}\right)^{n_0 m}$
One double-suction turbine at bottom of tank		$\frac{V_E}{Q}$	As in Tables II and III

Symposium on Process Industry Trends

Elsewhere in this report we have examined many of the technical and economic factors which determine whether a process is better conducted on a batch basis, or as a continuous or semi-continuous process. One job must still be done: assay the prospects for continuous processing in various process industries. The authors of the section which follows are men who know the industries of which they write. Whether their conclusions point to continuous processing as the aim, or not, they are valuable in showing the trend, for the aim is not continuous processing, but more efficient processing. For the remainder of this symposium, turn to pages 184 through 226.

DISTILLERY PROCESSES

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UNTIL a few years ago very little, if any research had been done in connection with distillery processes. However, within the last eight years significant progress has been made toward making all operations continuous instead of batch.

The first step in the process of making alcohol from grain is the conversion of the starch into fermentable sugars, usually referred to as cooking or mashing. A majority of distilleries employ large vats in which the grain is mixed with water, heated with sparged steam and agitated by means of large rakes. The complete cycle required for this operation from the time the water is added until the mash is cooled and pumped to the fermenters varies from 2 to 4 hr., depending on the type of grain. This type of cooking is not very suitable because it is inefficient and cumbersome.

A later development used in a few distilleries embodies the same type of operation as above except that the vessels operate under pressures up to 60-65 lb. These cookers are more efficient from a standpoint of converting starch to sugar but constitute no improvement in so far as reducing the number of operations and length of time required for a complete cycle.

The most recent development in cooking has been the continuous cooker. This process consists essentially of a small vessel in which grain, water and stillage are mixed into a slurry; a pump which forces the slurry through a heating jet where it is mixed with steam at a temperature of 350-360 deg. F.; a length of pipe designed to give 1-2 min. holding time; a chamber into which the cooked slurry is flashed and cooled by vacuum and mixed with a malt slurry. All of the operations are synchronized and automatically controlled. The time required for the complete operation is approximately 6 min.

A few of the advantages of the continuous system over the batch are: Approximately 80 percent less equipment is required; steam can be recovered for use in operating other equipment such as stills, evaporators, etc.; fewer workers are required; operations can be uniformly controlled, resulting in higher efficiencies; and cost of operation is lower.

A continuous cooker has also been developed for use where acid hydrolysis is desirable. It embodies the same general design as the above cooker except that dilute acid is added to the grain slurry which is later neutralized with $CaCO_3$ just before it is cooled in the flash chamber. A completely sterile mash results from this operation which makes it desirable for many types of fermentations. The corn sugar industry should be able to use this process.

A number of industrial alcohol plants installed the continuous cookers when converting over from molasses to grain at the beginning of the war alcohol program. Most of the new plants built for producing war alcohol have also installed continuous cookers. Today, approximately 10-12 percent of all alcohol produced in the United States is processed in plants using this type of cooking.

Yeasting and fermentation are the other principal operations left to be put on a continuous basis.

A process has been developed whereby yeast can be produced on a continuous basis from grain. The complete cycle has been reduced from 36 to 5 hr. and the volume of yeast tubs has thus been reduced to about one-seventh the total volume required using the batch method. The process consists of continuously mixing mash with nutrients, clarifying by means of filtration and centrifugation, sterilization of the wort, inoculation with yeast, propagation of yeast and, finally, centrifugation of the fermented yeast. Wort is continuously added to the fermenting vessel and finished yeast is continuously withdrawn.

This process has been developed and demonstrated on the pilot plant scale but has never been put into plant operation because of developments now being made on continuous fermentation which indicate it is not necessary. The process can be applied to commercial yeast manufacture as well as other types of fermentation employing yeast.

A continuous fermentation process which is essentially the same as the yeasting process has also been recently developed. A sterile mash produced by acid hydrolysis is continuously added to a fermenting vessel which has a capacity sufficient to allow a retention time of 8 hr., while at the same time an equivalent amount of mash is withdrawn to a beer well which has a capacity sufficient to allow a 2-hr. retention period. From the beer well the fermented mash is continuously fed to the stills. Nutrients are added in small quantities to the fermenter and the mash is under constant agitation. No yeast is added other than the

(Continued on page 184)

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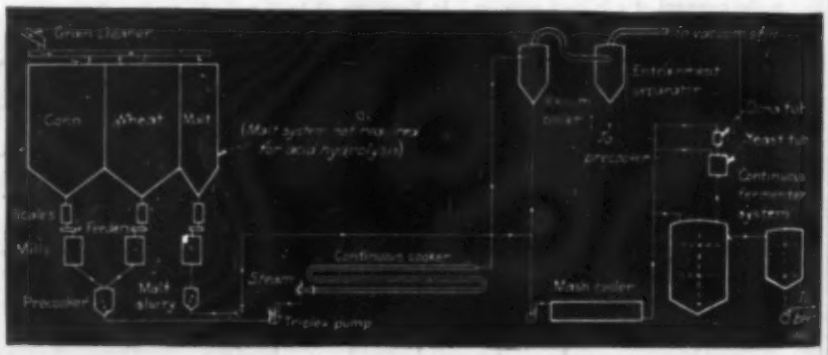

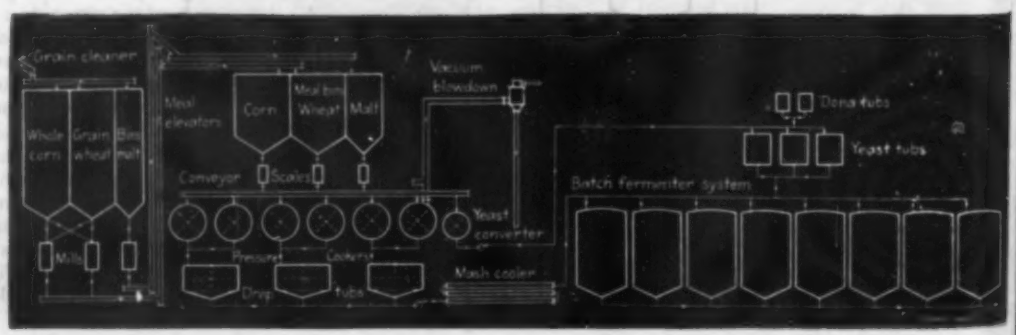

Above—Continuous cooking and fermenting

Right—Batch operation of distillery processes

Disposal of Government-Owned MAGNESIUM PLANTS

It is estimated that possible maximum postwar consumption of magnesium will approximate 65 million pounds with productive capacity exceeding 500 million pounds. The two concerns which appear most likely to survive the sharp contraction in consuming demand are Dow Chemical Co. and Permanente Metals Corp. Production at their plants is closely integrated with other operations carried on by them or their affiliates.—*Editors*

COMMERCIAL production of magnesium in the United States began in 1915 when the war cut off imports from Germany which had been the sole supplier of the metal to the rest of the world. Partly because of the high price then prevailing ($5 a lb.) and the abundance of raw materials, several concerns began production. During the following two years eight different companies operated magnesium plants, though not simultaneously. Most of these companies withdrew from the industry after the war, and by 1920 only two concerns remained—the Dow Chemical Co. and the American Magnesium Corp., which in 1919 had became a subsidiary of the Aluminum Company of America. In 1926 American Magnesium Corp. began purchasing a part of its metal requirements from Dow and in July, 1927, it discontinued production and purchased all its requirements.

Domestic production of magnesium increased in practically every year after 1921, although until 1939 the annual increments were relatively small. The increased demand resulting from the outbreak of the war in Europe was immediately felt in this country. Demand was further intensified by our own defense program which was first announced in May 1940. It became obvious that greatly expanded production facilities were required and several governmental agencies began to plan for expansion of the industry. Between 1939 and 1943 some 14 plants were built in the Unitied States with both government and private funds.

The first step in the government program was the action of the Office of Production Management in placing magnesium under mandatory priority status in March 1941. At about the same time the OPM endorsed the construction of the new plant of the Permanente Metals Corp. at Permanente, Calif., with money borrowed from the Reconstruction Finance Corp. Furthermore, negotiations were begun with several concerns for the building of additional plants and the National Academy of Sciences was requested to investigate all production processes other than the well-established electrolytic process, and to recommend an additional process which would give increased production quickly, assuredly, and with a minimum use of electric power. The Academy recommended the ferrosilicon process.

During 1941 and 1942 the Defense Plant Corp. contracted with 12 concerns for the building and operation for government account of 13 magnesium plants with an aggregate annual rated production capacity of 526,000,000 lb. Seven of these plants with a total annual capacity of 388,000,000 lb. were to use the electrolytic process, and the remaining six the ferrosilicon process. All contracts except one with Dow provided that the Defense Plant Corp. should pay all construction and operating costs and receive the proceeds from sales of metal, most of which had been for the manufacture of military supplies and equipment. All plants are owned by the government and managed by the various companies. Most contracts were for 10-year periods with provision for earlier cancellation, and each company was given the right of first refusal to buy the plant under its management at an arbitrated price if the government should decide to sell.

A somewhat different arrangement was made with Dow for the construction of the additional unit to that company's Freeport plant. Dow was to lease the plant site and only the cost for the building and machinery was to be borne by the Defense Plant Corp. The new plant was leased to Dow at an annual rental based upon the volume of production. After the termination of the lease Dow will have the right to purchase the plant at a price to be determined by a prescribed formula. Up to the end of September, 1944, the Defense Plant Corp. had expended $362,766,000 (net) for construction and equipment of plants.

EXCESS PRODUCTION

When the plants opened in 1942 and 1943 production of magnesium increased rapidly. Average monthly output rose from 8,000,000 lb. in 1942 to 30,000,000 lb. in 1943, and to more than 41,000,000 during the first quarter of 1944. This high rate of production proved to be far in excess of requirements, despite the fact that several government plants never reached rated capacity. Therefore, the War Production Board, between March and July, 1944, successively closed five government-owned plants and limited the output of four others. Several other plants have since been closed and production in all but four of the government-owned plants ceased by the end of 1944. Moreover, all restrictions on the use of magnesium have been removed. Four government-owned and three privately-owned plants are now in operation, and have a capacity of 134,000,000 lb. per year.

Expansion also occured in the fabrication branch of the industry. Formerly, the producers of metal were also the only fabricators, but in 1927 the American Magnesium Co. limited its activity to fabrication. Since the middle of 1930 the number of fabricators has steadily increased and this development was accelerated by the national defense and war program. The government has financed the construction of a number of fabrication plants at a cost of about $18,000,000. These government plants are leased to private operators who have the right of first refusal to purchase the plant under their control, if sale by the government is contemplated.

Magnesium is produced in the United States by two main processes: (1) Electrolysis of magnesium chloride, and (2) thermal reduction of magnesium oxide. The raw materials from which the chloride and oxide are obtained are underground brine, sea-water, waste liquors from potash manufacture, and ores containing magnesium,

Extracted from a report prepared by the U. S. Tariff Commission in response to requests from the Senate Committee on Finance and the House Committee on Ways and Means.

principally dolomite and magnesite. In the United States about 80 percent of the magnesium is now produced by electrolysis, but before the war this was the only method employed. The process used was that of the Dow Chemical Co., the only producer during the period 1928-40. Another electrolytic process, MEL method, developed by the British Magnesium Electron, Ltd., under German patents, has also been used in the United States since 1942. The basic difference between the two methods is in the degree of chemical dryness of the magnesium chloride as it is fed into the electrolytic cells.

The thermal reduction processes now used also fall into two groups—the carbothermal or Hansgirg process, and the ferrosilicon or Pidgeon process. These processes are based upon the ability at high temperatures of certain agents to reduce magnesium compounds to metallic magnesium. The carbothermal process, with carbon as the reducing agent, liberates magnesium in the form of dust which is then purified by distillation. The Pidgeon process, with ferrosilicon as the reducing agents, liberates magnesium in the form of vapor which is then condensed.

When magnesium was first produced commercially in the United States (1915) it was quoted in ingots at $5 a lb. Successive reductions brought the quoted price below $1 a lb. for the first time in 1925. The downward trend continued practically uninterrupted until 1932, when Dow fixed its offering price at 30c. a lb. It remained at that level until early in 1939 when it was reduced to 22.5c. a lb. This became the first ceiling price established by the Office of Price Administration April 28, 1942. The present ceiling price for ingots is 20.5c. a lb.

The costs of producing magnesium are indicated only imperfectly by the experience of the government owned plants. The plants were new. Some of them had hardly passed through a breaking-in period before production was curtailed. Moreover, there had been little experience with some of the processes employed. Costs, therefore, show considerable variation from plant to plant, and within each plant from month to month. With respect to eight plants which were operating either close to or above rated capacity in January, 1944, operating costs ranged from 12.8 to 31.5c. a lb., this not including depreciation and obsolescence. The simple average was 21.7c. The average of the lowest monthly cost experienced by these eight plants was 19.1c. a lb. The ceiling price of 20.5c. is about midway between these two averages.

No information is available on the prewar employment in the magnesium industry, but it is known that the number of persons employed was probably less than 1,000. It is estimated that by the end of January, 1944, the number had increased to 50,000. Of this number, about 18,000 were engaged in the production of primary ingots and an estimated 32,000 in fabrication. Since then, and largely as a result of the cutbacks in production, employment has steadily declined. Proportionately, the decrease has been largest in the primary branch of the industry, although the reduction in the absolute number employed in fabrication is estimated to have been only slightly less than that in production. Total employment at the end of December, 1944, is estimated to have declined to 26,000 persons, of whom about 5,500 were engaged in the production of the metal and an estimated 20,500 in the fabrication of the metal.

INTEGRATED PRODUCTION

Magnesium has been produced most successfully where it has been possible to integrate production with the electrolytic production of various chemical products. Countries with well developed electrochemical industries may therefore be expected to have an advantage in the production of magnesium after the war.

These favorable conditions for the production of magnesium are most obvious in Germany and the United States. In addition to these advantages, the two countries over a period of years have developed a know-how for producing and fabricating magnesium. For these reasons Germany and the United States should hold strong positions in the world market for magnesium after the war. If, however, Germany should be prohibited by the victorious nations from carrying on an industry so closely related to making war, the position of the United States should be exceptionally favorable. The total international trade in magnesium after the war, however, especially in the short term, is not likely to be very large. In many countries the demand will be small because the uses of the metal have not become well established and the art of fabrication is much less developed than in the United States and Germany.

Demand for magnesium in the immediate postwar period in the United States will be far less than the high wartime demand. There can be little doubt, however, that the use of the metal will be substantially greater after the war than it was before. Improvements in the methods of production and fabrication during the war, and reductions in the price of magnesium and its alloys, are likely to stimulate their use in applications which formerly were considered impracticable. The principle use of magnesium after the war is expected to be in aircraft and land vehicles, but sizable quantities will probably be used also in portable tools and office equipment and in aluminum alloys. At the maximum the average annual consumption of magnesium metal during the immediate postwar period will probably not much exceed 65,000,000 lb., although estimates of different experts range from much below to considerably above this figure.

In contrast to a possible maximum consumption of 65,000,000 lb. of primary magnesium per year in the immediate postwar period, the United States will have a production capacity of over 500,000,000 lb. a year at the end of the war. Even allowing for considerable error in estimating probable consumption, it is evident that our production capacity far exceeds immediate postwar requirements. The investment of the government in the II plants which it owns amounts to $363,000,000; the disposition of these plants and the salvage of as much of the investment as possible is obviously an important postwar problem.

The principal postwar problems of policy regarding magnesium are concerned not s

Rated Annual Production Capacity of Magnesium Plants in the United States

Ownership and Operating Company	Location of Plant	Process Used	Rated Capacity Million Pounds
Privately owned:			
Dow Chemical Co.	Midland, Mich.	Electrolytic	18
Dow Chemical Co.	Freeport, Tex.	Electrolytic	18
Permanente Metals Corp.	Permanente, Calif.	Carbothermic	24
Total privately owned			60
Government owned:			
Dow Chemical Co.	Freeport, Tex.	Electrolytic	18
Dow Magnesium Co.	Velasco, Tex.	Electrolytic	72
Dow Magnesium Co.	Marysville, Mich.	Electrolytic	72
International Minerals and Chemical Co.	Austin, Tex.	Electrolytic	24
Diamond Magnesium Co.	Painesville, Ohio	Electrolytic	36
Basic Magnesium, Inc.	Las Vegas, Nev.	Electrolytic	112
Mathieson Alkali Works, Inc.	Lake Charles, La.	Electrolytic	54
New England Lime Co.	Canaan, Conn.	Ferrosilicon	10
Magnesium Reduction Co.	Luckey, Ohio	Ferrosilicon	10
Electro Metallurgical Co.	Spokane, Wash.	Ferrosilicon	48
Ford Motor Co.	Dearborn, Mich.	Ferrosilicon	40
Ameo Magnesium Corp.	Wingdale, N. Y.	Ferrosilicon	10
Permanente Metals Corp.	Manteca, Calif.	Ferrosilicon	20
Total government owned			526
Grand Total			586

Compiled by the U. S. Tariff Commission.

much with the tariff and imports as with the organization and control of the domestic industry. More specifically, these problems arise from the possibility that competition in the domestic industry may be lacking, or at least relatively ineffective, and from the implications this possibility may have as to national security in the general welfare. This possibility is one of the considerations in the disposal of government-owned plants.

The two concerns which seem most likely to survive the great reduction in demand for magnesium which is bound to take place after the war are the Dow Chemical Co. and the Permanente Metals Corp. The plants of both these companies are integrated with other operations of the same or affiliated companies.

Dow owns outright plants at Midland, Mich., and Freeport, Tex., which, together, have a capacity of about 36,000,000 lb. To the Freeport plant the government has built an addition which Dow operates under lease. Dow holds a 90-day option for the purchase of this plant at the close of the war at a price specified in the contract. If Dow exercises this option its capacity will be about 54,000,000 lb., five-sixths of what may be the maximum national requirements in the immediate postwar period and approximately equal to the probable requirements outside of the Pacific Coast area. If Dow does not purchase this addition, it will probably not be technically feasible for any other private concerns to take the addition over because of its intimate relation to the Dow-owned plant. Moreover, for the same reason, it would probably not be practicable for the government to operate this property on its own account.

With or without the addition of the Freeport plant, Dow seems bound to be much the largest concern in the industry after the war. Certain factors, however, may weaken the postwar position of Dow in the industry compared with its prewar position of complete monopoly. One of these factors is the change in the system of fabrication patents. The consent decree of April, 1942, opened the 100-odd fabrication patents held by Dow royalty-free to any fabricator. Fabricators will, therefore, be more free than they were to purchase the metal from concerns other than Dow. Moreover, future technological development may challenge the present superiority of the Dow seawater plants in cost of production. Even if Dow should for a time be the only domestic producer of magnesium east of the Pacific Coast, its price policy would presumably be materially affected by the potentiality of competition from the Permanente Corp.

The carbothermic magnesium plant privately owned by the Permanente Metals Corp. at Permanente, Calif., is one of the enterprises controlled by Henry J. Kaiser. It has a capacity of 24,000,000 lb. per year. Much of its output in the postwar period could probably be sold on the Pacific Coast, particularly to other Kaiser enterprises. In attempting to sell in the eastern and central markets, however, it would be at a disadvantage because of transportation charges.

Cost of Magnesium Production for Specified Government-Owned Plants*

Operating Companies	Cost and Operating Rate in January 1944		Lowest Monthly Cost	
	Cost (C. per Lb.)	Percent Rated Capacity	Cost (C. per Lb.)	Percent Rated Capacity
Dow Chemical Co., Velasco, Tex.	12.8	116.7	11.5	112.1
Dow Chemical Co., Marysville, Mich.	20.0	99.7	18.4	89.3
Diamond Magnesium Co., Painesville, Ohio	17.4	108.0	16.6	91.0
International Mineral & Chemical Co., Austin, Tex.	23.3	98.4	20.3	103.3
Basic Magnesium, Inc., Las Vegas, Nev.	20.0	107.2	18.0	66.3
Magnesium Reduction Co., Luckey, Ohio	19.8	123.9	18.3	125.2
New England Lime Co., Canaan, Conn.	31.5	91.2	22.2	79.3
Permanente Metals Corp., Manteca, Calif.	28.5	112.8		105.8
Simple average cost of all plants listed	21.7		19.1	

* Cost figures do not include allowance for depreciation and obsolescence.

DISPOSAL PROBLEMS

Whether the government can dispose of any of the considerable number of other magnesium plants which it owns, so as to foster competition in the industry after the war, is somewhat uncertain. The private concerns which have operated plants for the government would probably not want to take a plant over from the government. They would do so only if they were convinced that the foregoing estimate of immediate postwar consumption is far too low or that a particular plant could produce at costs lower than those of the privately owned plants of Dow and Permanente, which, together, have a capacity approaching if not exceeding the probable maximum demand. There is little to indicate that any of the government plants can operate at costs as low as those of Dow. The plants which operate by the ferrosilicon process particularly have a history of much higher cost than the electrolytic plants. Moreover, several government plants have very large units which could operate advantageously only with a very large output, a circumstance which will impede the disposal of them.

One government plant which might possibly attract private concerns other than Dow is the one at Velasco, Tex., now operated by Dow for the government but on which Dow holds no option. This plant uses the Dow electrolytic process for which presumably some royalty would have to be paid to Dow. Unlike the plants owned by Dow, the production of magnesium at Velasco is not at present integrated with chemical production. This fact would place any concern operating it at a competitive disadvantage unless the concern could adapt the plant to the production of other products as well as magnesium.

For one reason or another, location, efficiency, cost, size and the like, it seems rather doubtful whether the present operators of any of the other government-owned plants will be disposed to take them over for private operation, or that other concerns will wish to do so. There is, however, the possibility that some of the plants might be so taken over.

The government also has the problem of disposing of its present stocks of magnesium. It holds about 100,000,000 lb. as a surplus above current operating requirements. Although this reserve is equivalent to less than three months' consumption at the peak wartime rate, it is equal to one or two years of probable postwar consumption. Were it not for the tendency toward oxidation of the metal, these reserves could, of course, be held as an emergency stockpile. To throw them on the market at the close of hostilities, on the other hand, would seriously affect the industry. Private concerns would probably curtail or even suspend the primary production of magnesium, especially if the government offered its reserves at a low price, until these reserves would have been absorbed.

To date the plant using the carbothermal process, the Permanente plant of the Permanente Metals Corp., is the only one in the United States known to be marketing a byproduct of magnesium production to outside customers. This byproduct is magnesium black, a mixture of carbon magnesium oxide and magnesium dust which is left as the residue from the distillation of the "goop." It is sold to the synthetic rubber, refractory and rayon industries. The electrolytic process has at least a potential prospect of producing excess chlorine, caustic soda and sodium products at those plants where it is found to be economic practice to prepare chlorine for plant use by the electrolysis of brine. So far as is known, no marketable byproducts have been obtained from the operation of the ferrosilicon process plant, although much research is being carried on to develop a market for the waste calcium-iron-silicate residue.

FROM THE VIEWPOINT OF THE EDITORS——

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PRESIDENT TRUMAN

WHAT may the chemical process industries expect from the new President of the United States? While Mr. Truman has not been associated with legislation pertaining specifically to this group of industries, many of the measures that he has either advocated or opposed have a direct bearing on the group. We look at his record and we look behind the record at the man himself, and we find much in both that is reassuring to these industries and to the chemists and engineers throughout this land of ours.

That he has a fund of detailed information concerning public expenditures and that he has very fixed ideas that tremendous economies can be accomplished in his administration without in the slightest measure interrupting the war program seems to us the first and far from the least important item in the record. Already he has announced reductions in government expenditures in excess of $7 billion and that other cuts in expenditures are under consideration.

The new President considers himself a liberal, but he is not attracted to what he calls "professional liberals." There were many such liberals in the last administration, but we have the soundest of reasons for believing that we shall find Mr. Truman will not be greatly guided by this faction and that its members will gradually disappear from Washington.

That he is in favor of social legislation he so stated in a Labor Day speech in Detroit last year and also pledged that human welfare would be put first and profits second in returning to a peacetime economy. "We shall not, for the sake of price and profit, restrict our output. Rather, for the sake of our people, we shall return to the 40-hour week and increased basic wages in terms of actual purchasing power."

It is part of the record that he has come out strongly for support of the Office of Price Administration and the Stabilization Act. There is every reason to believe that he is in favor of relieving the pressure somewhat by resumption and expansion of civilian goods as rapidly as the Japanese war will permit. Mr. Truman, it will be recalled, initiated the reconversion program developed by WPB last year, putting pressure on its executives to work out a detailed plan for dropping wartime controls as promptly as possible after Germany's defeat.

As for taxes, we believe that Mr. Truman may not recommend complete elimination of the excess profit tax, more or less automatically, after Japan is defeated. The budget in the first year after V-J Day will be large and that with some recession in the over-all level of business, there still will be required some deficit financing without any reduction in present tax rates.

Mr. Truman has reappointed David E. Lilienthal as chairman of the Tennessee Valley Authority for another nine-year term, notwithstanding the vigorous protest of the politically distinguished Senators from Tennessee. In his message vetoing the farm deferment resolution he stated that the legislation would single out one special class of our citizens, the agricultural group, and put it on a plane above both industrial occupation and military service. He has asked Congress to extend reciprocal trade treaty legislation without change.

It is part of the record, too, that the new President supported Roosevelt's policies except in a few more or less important particulars. His opposition is recorded in his vote against the $25,000 salary limit, against sustaining presidential veto of the 1936 soldier bonus payment, and last year's tax bill. He stood with the last administration on the Wagner Act and was against the Connally-Smith antistrike act. He voted for lend-lease.

Such is the record of this typical American who has suddenly and unexpectedly risen to the highest office in the nation. What his attitude may be on some of the problems more specifically of interest to the process industries, we can only approximate from a consideration of the man himself and his record.

RESEARCH EDUCATION

BATTELLE Memorial Institute is planning its postwar programs to advance the professional training of young scientists and technologists as well as to add to the world's store of basic scientific knowledge. For these two purposes it has selected a new director of research education and has announced graduate fellowships for promising young investigators. Thus one institution recognizes its responsibilities and undertakes to do something about it.

Many of the educational institutions of this country are struggling with a comparable problem. Few industrial executives and chemical engineers fully appreciate the difficulties being experienced. At a time when money for research is more widely available than ever before it is not easy to understand the limitations of salary scales and the difficulties of getting proper faculty leadership. But these problems are very real, and very important to industry.

Industry has two methods of procedure open to it. Both should be used freely. Industry can give funds and facilities to stimulate institutional and college training for research without any strings on the money. That is a very good plan in many cases. But the time appears to have come when some managements are going to have to establish at appropriate institutions certain research training fellowships in which the young fellows will be more or less obligated to work with the sponsor company for at least a limited period of actual service. It is unfortunate

that such a string should sometimes be necessary on funds given to aid in research training. But the demand for trained young men is now so great that those who wish to get some benefit from their donations are almost compelled to use this method for a part of their contributions to educational programs.

The job is a tremendous one. The need of advance training in research methods will greatly exceed the facilities available to furnish this training for some years to come. This is only one evidence of the postwar shortage of highly skilled professional manpower.

A CO-OP IS PRIVATE INDUSTRY

THE National Planning Association in its publication "Fertilizers in the Postwar National Economy" makes the very significant statement, "Private industry includes farm cooperatives. The latter should be given the same opportunities to participate in the fertilizer industry as other branches of private industry." Thus an organization that represents industry, labor, agriculture, and almost every other important division of American enterprise accepts the farm cooperative as a natural proper part of American business.

As a broad principle we are inclined to agree with NPA but we venture to say that not all farm co-ops deserve compliments for the part they play in business dealings. If all were as meticulous in meeting their obligations and transacting dealings as some, there would be no question as to their standing in our minds. But we must confess that even in our favorite industries we find some seem to prefer low standards of business dealings. We therefore hope and we expect that the co-op will grow in recognition and acceptance as it grows in responsibility and proper participation in business dealings.

These are important matters for quite a number of divisions of chemical process industry. A great deal of the ultimate market for chemicals and other products of our industries is on the farm. Our merchandising programs must take account of the proper role of the farm co-op in accomplishing effective distribution for all of these things.

IS NITRATE EXOTIC?

FROM comments of those persons interested in natural Chilean nitrate one might think that synthetic sodium nitrate was an exotic product in the United States. Let us consider the facts. Natural nitrate delivered in the United States under present circumstances costs more than $36 per ton for Chilean costs, transport, proper handling charges and dealer margins. Were there not a subsidy of more than $6 per ton granted by the United States government the market price could not be maintained at the present level of $30.

Synthetic sodium nitrate can be made and marketed at a very much lower cost without any subsidy, hidden or direct. Manufacturers in the postwar period would be delighted if they thought they were going to get such a price for the product made from synthetic ammonia and soda ash.

It seems absurd under these conditions to regard as unfair the competition of the synthetic product with the imported high cost product from Chile. Only the theory that we must not have technical advance interfere with vested natural processes could possibly justify the recent efforts to restrict synthetic manufacture. The synthetic product must be allowed to fill the fertilizer market as long as it can do so with a profit at a price lower than that which the farmer must pay for imported sodium nitrate.

We trust that the State Department will withdraw from the unwarranted position which it has taken in an effort to buy Latin American favor.

HANDLE THOSE EMPTIES!

RAILROADS and shippers have lately been criticizing each other about improper handling of empty gas cylinders and empty drums. It is time that bickering should end and some constructive careful steps taken for correction of the serious mishandling of empty containers.

The shippers of empties must be more careful to sort them into groups, label correctly, and prepare proper waybills for their shipment by both truck and rail. These shippers must not expect overworked transportation employees to know the destination. Those who want the containers returned for refilling need to educate their customers who ship the empties regarding these responsibilities.

The railroad and truck groups getting these empties for a return haul can well instruct employees to accept them only when sorted according to destination and properly billed for convenient handling. It does little good for the railroads of the country to complain about bad practice after they have mistakenly accepted improper shipments.

Companies which want these empties returned may even find it necessary to go to extreme measures to stimulate good practice. If customers do not return empties properly, it might well be arranged that they get no new full containers. Certainly the users of the contents have a moral responsibility under present difficult conditions to care for the containers and see that they start back properly for refilling. If they do not accept this responsibility they can well do without contents that must be shipped in other containers or they deprive other more deserving customers of their rights.

MARTIN HILL ITTNER, 1870-1945

OUR CHEMICAL industry and profession has lost a distinguished leader. Dr. Martin H. Ittner is dead. For a half century he contributed much of his time, and thought and energy to their development. During the 50 years that he directed the research of the Colgate company he made many technical contributions for which he was awarded the Perkin Medal in 1942. Equally worthy were his extra-curricular activities. He served as president of the American Institute of Chemical Engineers, and as president of the Chemist Club. In 1936, he went to London as chairman of the American delegation to the first International Chemical Engineering Congress. He was an unselfish worker for the welfare of the profession, serving on numerous committees. It was in these meetings that we most often met Martin Ittner, that we got to know his rare judgment, his exacting fairness, and witnessed his indomitable courage to fight, if necessary, for his convictions.

PROCESS EQUIPMENT NEWS

THEODORE R. OLIVE, Associate Editor

MECHANICAL VACUUM PUMP

FOR CONTINUOUS service at pressures as low as 5 microns absolute, the F. J. Stokes Machine Co., Philadelphia 20, Pa., has developed the Model 212 Microvac oil-sealed rotary vacuum pump which has a displacement of 100 cu. ft. at 350 r.p.m. The pump is simpler in design, more rugged, and higher in volumetric efficiency and capacity than the model it supersedes. It has but four internal moving parts: a shaft with keyed on eccentric, a rotating one-piece piston and slide, and the hinge bars. The design eliminates dead space, permitting discharge of the air at the end of each stroke to be complete without the re-expansion which impairs efficiency. The pump is driven with a V-belt drive from a motor mounted on an adjustable hinged base on top of the pump. Smooth operation is assured by careful balancing of the flywheel. Oil baffles built into the base are provided to remove entrained oil from the exhaust.

FLOAT LEVEL CONTROLLER

PACKLESS liquid level controllers of the float type manufactured by Moore Products Co., H and Lycoming Sts., Philadelphia 24, Pa., have been described in a number of earlier modifications in these pages. The manufacturer has now announced a new type for service under extremely corrosive conditions in which all parts coming in contact with the liquid are fabricated from Hastelloy B. This is, according to the manufacturer, the first time that this high-strength, corrosion-resisting alloy has been applied to level control instruments. In these instruments the motion of the float is transmitted to the piloting mechanism through a packless flexible shaft. The center section of the flexible shaft is similar to a bourdon tube in cross section and acts as a flexible pivot for the float. An extension tongue running through the flexible section of the shaft extends beyond the flange shown in the accompanying illustration, operating the pilot air valve with changes in float position.

ELECTRIC SPEED INDICATOR

RELIABLE, low-cost electric speed indication is claimed for the new indicator available for speeds from 100 to 5,000 r.p.m. from Reliance Electric & Engineering Co., Cleveland, Ohio. The pick-up unit is a miniature six-pole alternator with a permanent magnet rotor which is mounted on the shaft whose speed is to be measured. The indicator, a permanent-magnet, moving-coil type, meters the pick-up output on a 3½-in. scale which covers 95 deg. of arc. The resistance of the indicator is high enough so that neither size nor length of the leads connecting the units have an appreciable effect on accuracy. Hence the indicator may be located at any desired distance from the pick-up unit. Indication is instantaneous and continuous and is independent of the direction of rotation of the shaft. Since the pick-up is without commutator or slip rings and since the instruments are provided with lifetime lubrication, maintenance is said to be extremely simple. A variety of scale ranges is provided including full-scale deflection corresponding to 1,500, 2,000, 2,500, 3,000 and 5,000 r.p.m. Special scales may be secured reading in such units as feet per minute, if desired.

WET DUST COLLECTOR

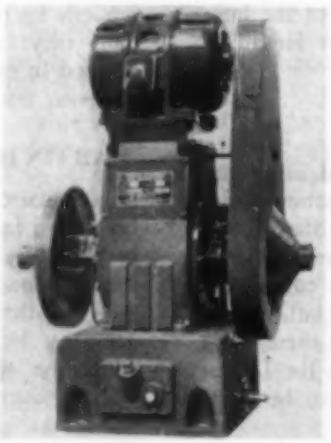
NO MOVING PARTS are required in the Type N collector recently added to the Roto-Clone series of dust collecting equipment made by American Air Filter Co., Louisville 8, Ky. The air is cleaned by a combination of centrifugal force and intimate intermixing of water and the dust-laden air. As appears from the accompanying illustration, the air is forced through a sinuous passage sealed by water in the bottom of the collector, inducing a heavy sheet of water to move along the surfaces of the element forming the sinuous passage and creating a water curtain in the form of a reversible S, through which the air must penetrate. The new collector is thus said to have high collection efficiency and to be safe in the handling of explosive dusts. This device is manufactured in three classes and 13 sizes for the exhausting of air in capacities from 1,000 to 25,000 c.f.m.

THERMOSTATIC TRAP

A MUCH wider field for thermostatic steam traps than formerly is now said to be possible through the development of a new line of such traps for pressures up to 225 lb. per sq.in., using a single large diameter bellows, for outlet sizes from ½ to 2 in. inclusive. The manufacturer of these traps, Sarco Co., Inc., 475 Fifth Ave., New York 17, N. Y., states that the development was made possible through improved means of manufacturing bellows from heavy-wall bronze tubing which is drawn and helically corrugated in the company's own plant by its own method. Two pressure ranges are now available, one for pressures to 100 and the other for pressures to 225 lb. per sq.in.

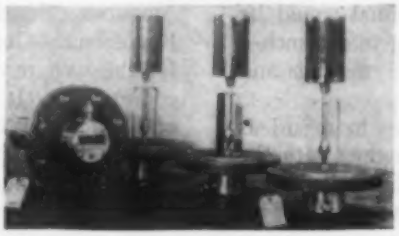
Heavy construction is employed, with the heavy-wall bellows screwed into the end closures and the joints sealed by brazing, employing electronic induction heating equipment. The new traps are said

High efficiency high vacuum pump



Electric speed indicator

New Hastelloy level controllers



Wet-type dust collector

to have much higher condensate capacities in the same size, at the same operating pressure, compared with earlier traps. For example, operating at 100 lb., the condensate capacity of the company's older 1-in. trap was 2,000 lb. per hr., compared with 5,200 lb. per hr. for the new 1-in. trap. Six sizes, from ½ to 2 in., are now produced.

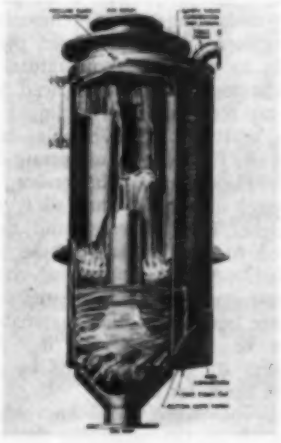
GATHERING PUMPS

DESIGNED primarily for gathering in oil fields, a new pump developed by Blackmer Pump Co., Grand Rapids 9, Mich., is available in a capacity of 90 g.p.m. for pressures up to 500 lb. per sq.in. The pump, reduction gearing, clutch and prime mover are mounted on a fabricated steel skid, making a compact unit which is easily moved in the field. Leakage is practically eliminated by the use of a stuffing box so designed that vacuum is maintained on the packing chamber. The pump is claimed to have a mechanical efficiency of 85 percent at 500 lb. per sq.in., and to be specially designed for outdoor service.

HEAT RECOVERY SILENCER

AN IMPROVED combination silencer and boiler for the production of either steam or hot water from the exhaust of diesel engines has been announced by Engineering Specialties Co., 39 Cortland St., New York 7, N. Y. Known as the Vortex heat-recovery silencer, the device combines in one construction the four functions of steam generation at pressures up to 30 lb. per sq.in., hot-water heating, exhaust silencing and the removing of sparks and carbon from the exhaust gases. The silencer occupies little more space than an ordinary spark arrester-silencer without the steam or hot water features. It's efficiency as a steam producer is said to be exceptionally high for this type of service, due to improved methods of heat conduction and to the means employed for removing carbon from the exhaust gases in the lower part of the apparatus, before the carbon can deposit on the heat transfer surfaces.

New heat recovery silencer for diesels



Triple range hand tachometer

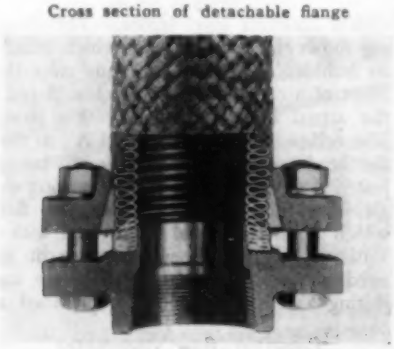
METAL HOSE FLANGE

SIZES of 2, 2½ and 3 in. inside diameter are available in a new detachable flange for helical flexible metal hose, produced by Packless Metal Products Corp., New Rochelle, N. Y. This flange is designed to permit repeated reuse and can be installed with ordinary shop tools. No brazing is required. Gaskets are not employed in connecting the flange to the hose, so that an actual metal-to-metal seal is secured.

ELECTROSTATIC SPRAYING

ELECTROSTATIC spraying, which has for several years been of interest in the industrial application of finishes such as paints and varnishes, is now being employed commercially in the porcelain enameling industry. Several years ago the use of electrostatic spraying of paints was developed by the Harper J. Ransburg Co. of Indianapolis. During 1944 the Pemco Corp., Baltimore, Md., became interested in the possibilities of electrostatic spraying in the application of porcelain enamels and secured experimental equipment from the Ransburg organization. The tests are said to have shown that electrostatic spraying is a satisfactory method of coating materials to be porcelain-enameled and when properly used insures a uniformly coated product with a minimum of over-spraying. Information on costs and availability of the apparatus can be secured from either the Ransburg or Pemco organizations.

Cross section of detachable flange



Safety coat and trousers

HAND TACHOMETER

MODEL J is the designation of a new triple-range hand tachometer, now being offered by Herman H. Sticht Co., 27 Park Place, New York 7, N. Y. The instrument is available for speeds as low as 100 r.p.m., and as high as 15,000 r.p.m. Various range combinations may be secured. In any one instrument any of three ranges may be selected. The instrument has a gear shift for setting to low, medium or high range, secured by moving the drive shaft up or down by loosening and then tightening a thumb screw. These instruments are of the centrifugal, mechanical type, indicating speed and changes of speed instantaneously. They are permanently lubricated and are supplied with 4-in. black dials, calibrated with large, white figures, easy to read at a distance.

SAFETY CLOTHING

PROTECTION against a wide variety of industrial hazards including oils, acids, caustics, water, dust and fumes can be had in a complete line of Ply-Garb clothing for both men and women operators now being offered by The Milburn Co., Detroit, Mich. The improved and augmented line now includes sleeves, aprons, overalls, coveralls, slacks, jackets, cape sleeves and bib combinations as well as caps and hoods. The material employed for Ply-Garb clothing is said to afford a maximum of protection with a minimum of weight, sometimes being from two to five times lighter than conventional garments for the same purpose. A special cotton or duck processed with plastic is used, in both single- and double-coated fabrics for ordinary or heavy-duty wear.

RADIATION PYROMETER

DIFFICULTY is frequently encountered with radiation pyrometers due to change in the characteristics of the instrument through penetration of air or gases into the instrument inclosure. Brown Instrument Co., Philadelphia, Pa., has introduced five improvements for its Radiamatic compensated radiation pyrometer which are said to secure it against air and gases up to 1 lb. per sq.in. gage pressure at temperatures to 250 deg. F. The improvements include use of an adhesive sealing compound between the lens and mounting ring; use of brass for the lens retaining and mounting rings; employment of controlled torque in assembling; use of milled slots instead of spanner wrench holes in the lens mounting ring to avoid cutting through the ring face; and, finally, more positive sealing of the sighting glass located at the rear of the thermopile assembly.

CHEM. & MET. PLANT NOTEBOOK

THEODORE R. OLIVE, Associate Editor

$50 WAR BOND FOR A GOOD IDEA!

Until further notice the editors of *Chem. & Met.* will award a $50 Series E War Bond each month to the author of the best short article received during the *preceding* month and accepted for publication in the "*Chem. & Met. Plant Notebook.*" Articles will be judged during the month following receipt, and the award announced in the issue of that month. The judges will be the editors of *Chem. & Met.* Non-winning articles submitted for this contest may be published if acceptable, and if published will be paid for at space rates applying to this department.

Any reader of *Chem. & Met.*, other than a McGraw-Hill employee, may submit as many entries for this contest as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 300 words, but illustrated if possible. Neither finished drawings nor polished writing are necessary, since only appropriateness, novelty and usefulness of the ideas presented are criteria of the judging.

Articles may deal with any sort of plant or production "kink" or shortcut that will be of interest to chemical engineers in the process industries. In addition, novel means of presenting useful data, as well as new cost-cutting ideas, are acceptable. Address entries to Plant Notebook Editor, *Chem. & Met.*, 330 West 42nd St., New York 18, N. Y.

APRIL WINNER!

A $50 Series E War Bond will be issued in the name of

MAX SAMFIELD
Bureau of Industrial Chemistry
University of Texas
Austin, Texas

For an article dealing with a simple device for maintaining a low pressure differential which has been adjudged the winner of our April contest.

This article will appear in our June issue. Watch for it!

March Contest Prize Winner

RELATIVE VISCOSITY MEASUREMENTS MADE WITH CONSTANT LEVEL FLOW VISCOMETER

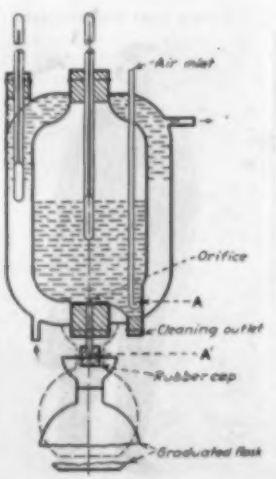
NEO S. SERINIS
Senior Project Engineer
Owens-Illinois Glass Co.
Berlin, N. J.

RELATIVE viscosity measurements may easily be made with the viscometer described below. The main feature that differentiates this instrument from others of similar principle is the automatic control of the flow rate through control of the hydrostatic head on the orifice. This arrangement lends itself to the use of a minimum hydrostatic head to sustain flow and permits the use of comparatively large orifices, without destroying the viscous flow of the liquid.

This development came about through the discovery that it was possible to obtain a viscous flow of water through an orifice 5 mm. in diameter with a hydrostatic head of 25 mm. Since a method was available for accurately holding such a head it seemed evident that considerable accuracy could be achieved in measuring the relative viscosities of liquids similar to or less viscous than water. Furthermore, it was evident that orifices of the magnitude indicated would be adaptable to the viscous flow of liquids many times more viscous than water, without inordinately long flow periods. This would make possible the direct relative measurements of widely divergent viscosities, with water as the basis of comparison.

The drawing shows a cross section of the viscometer and is largely self-explanatory. The method used to maintain a constant hydrostatic head has been described recently by the author (*Chem. & Met.*, Jan. 1945, p. 117) in connection with a constant level feeder. The drawing shows the air inlet tube which admits air bubbles at level A and thus gives the effect of a constant liquid level at A until the actual level drops below this point. The orifice is indicated at level A', so that the head on the orifice, which can be adjusted if desired by raising or lowering the air inlet tube, is A-A'. The glass flask which holds the liquid is provided with a water jacket through which water of desired temperature is circulated before and during a test. An outlet is provided at the bottom for cleaning and flushing the vessel. A small graduated flask to receive the flow is designed to be raised into partial contact with the viscometer during use to minimize loss by evaporation. A rubber cap over the orifice is removed when flow is to be started.

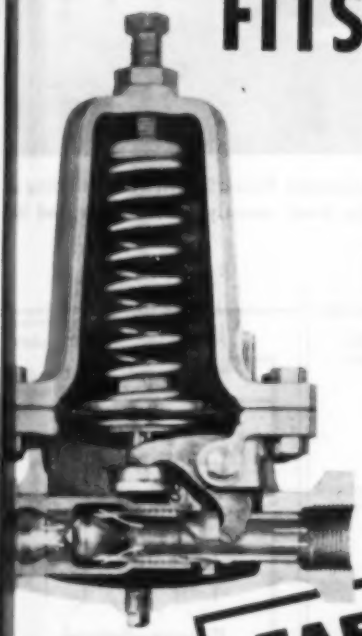
Constant flow viscometer



Use of the instrument is simple. The jacket circulating water temperature is first regulated and the sample, previously brought to the same temperature, is run in. The top stopper is replaced and the lower cap removed, allowing liquid to flow into a beaker until air bubbles begin to rise at A. Then the measuring flask is quickly placed under the orifice, as the stop watch is started. The flask is raised to the higher level indicated and the time required to fill the flask to the mark is recorded. After cleaning the viscometer the same operations are repeated with the reference liquid and other materials which are to be compared with it. Relative viscosities are then computed by comparing the times for flow.

Any convenient size for either the viscometer or the measuring flask can be used satisfactorily. However, in the case of liquids of lower viscosity, it may be desirable to employ larger vessels or smaller orifices so that the flow time will be sufficient for close measurement. With more viscous liquids, larger orifices, or smaller volumes may be desired to avoid prolonging the flow time unduly. Owing to the constant head used the delivery rate is independent of the time that flow has been taking place, so that it is possible to compare liquids of widely varying viscosity without changing orifices, simply by comparing the volumes of flow for the same time. If two different orifices are to be used it is of course necessary to calibrate the second in terms of the first by use of the same reference liquid.

THIS *Streamlined Design* FITS THE JOB . . . .



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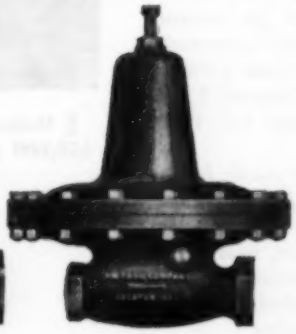


Type 1000—LP
Has large diaphragm.
Made for low delivery pressure.

CASH STANDARD *Streamlined* TYPE 1000 PRESSURE REDUCING VALVES

- Trouble-free service
- Smooth operation
- Tight closure
- Accurate regulation
- Elimination of failures
- Constant delivery pressure
- No spoilage
- Maintenance needs practically zero
- Speedier production results
- Cost-saving operation

ou may not have realized previously the exact alue Streamlined flow around the inner valve can ave for a line such as yours.

he "1000" does assure you such performance as the llowing . . . maximum capacity when needed most . . accurate pressure control under tough operating onditions . . . no variations in the reduced pressure . wide opening valve that permits of maximum flow. efore you get your "1000" valve it is made to work nder the identical pressure conditions given on your urchase order. We make sure in this way that it fits he job . . . we do know that Streamlined flow is right or the job and you will quickly find it so.

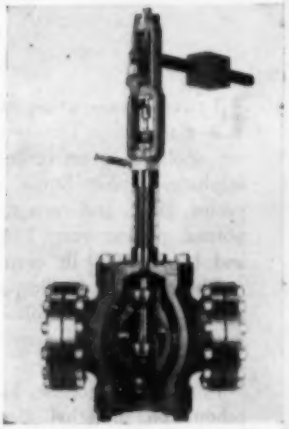
●

Bulletin "1000" gives you details on elimination of erratic pressure, savings in operating and maintenance costs, and complete performance facts of the CASH STANDARD Streamlined Type 1000 Pressure Reducing Valve.

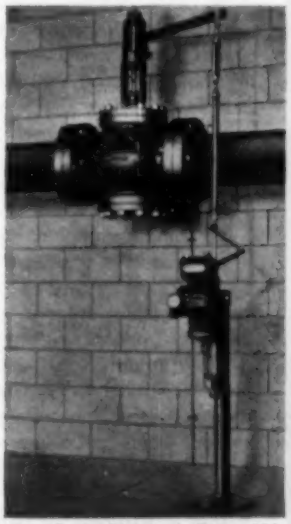
CASH STANDARD CONTROLS . . VALVES

A. W. CASH COMPANY
DECATUR, ILLINOIS

OTHER VALVES *from the* CASH STANDARD LINE



Cash Standard Balanced Valves, Series 42, have no lost motion. Have roller guides that kill side strains; stop packing trouble. Practically no maintenance. Sizes ½" to 12"; pressures up to 600 lbs. temperatures to 800° F. Bodies: iron, bronze, steel; all standard trims. With Air Cooled Packing Box (42-AC-R) shown above; or water cooled; or no cooling box. Made also with center guide. Bulletin 965.



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Type 100 Controllers have lots of operating power, enough for any size valve; are fully compensated; have adjustable range; are very sensitive. Bulletin 963 covering the Controller and Bulletin 965 covering the Valve give complete and interesting details. Write for them.

☆

MOLASSES DISTILLATION

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The molasses distillery depicted here is that of the Pennsylvania Alcohol and Chemical Corp., subsidiary of the Pennsylvania Sugar Co., Philadelphia, Pa.

In the past, molasses has served mainly for the production of ethyl alcohol. All indications, however, show that the trend in the future will be to recover products such as yeast, solid carbon dioxide, fertilizer, decolorizing carbon, feedstuff, and potash products—with ethyl alcohol probably relegated to the position of byproduct.

The process steps yielding these products are as follows: (1) Pasteurization of molasses, addition of sulphuric acid, and removal of the precipitated calcium sulphate in solid basket centrifugals. (2) Flash cooling the clear mash and diluting with cold water. (3) Preparation of pure yeast culture, propagation in yeast tubs, addition to the diluted molasses, and fermentation. (4) Separation of the yeast from the beer in De Laval separators, washing the yeast slurry and drying. (5) Simultaneously de-alcoholizing the yeast-free beer and concentrating the stillage in multiple effect evaporators. (6) Recovery of low wine (50° proof) as condensate in the evaporator's second effect and its distillation. (7) Compression and liquefaction of CO_2 gas after it has been scrubbed with water and deodorized with chemicals. (8) Production of solid carbon dioxide (dry ice) by expanding liquid CO_2 in "snow" presses and recompression of expanded gas from presses. (9) Concentrated stillage, made alkaline, is first carbonized at low temperature, then activated. (10) Potash separated from the carbon yields potassium carbonate or hydrate. (11) Crude carbon is purified and dried, resulting in decolorizing carbon. (12) Gas from the retorts is scrubbed to remove tar and ammonia and is used as fuel for the retorts.

Not all of these operations are in actual plant operation at the present time. In particular, the entire stillage recovery plant has progressed only as far as successful pilot-plant trials, though a full scale plant has been designed and blueprinted and awaits only the end of the war for construction. As the plant now stands, there is no provision at all for recovering the valuable byproducts in the stillage.

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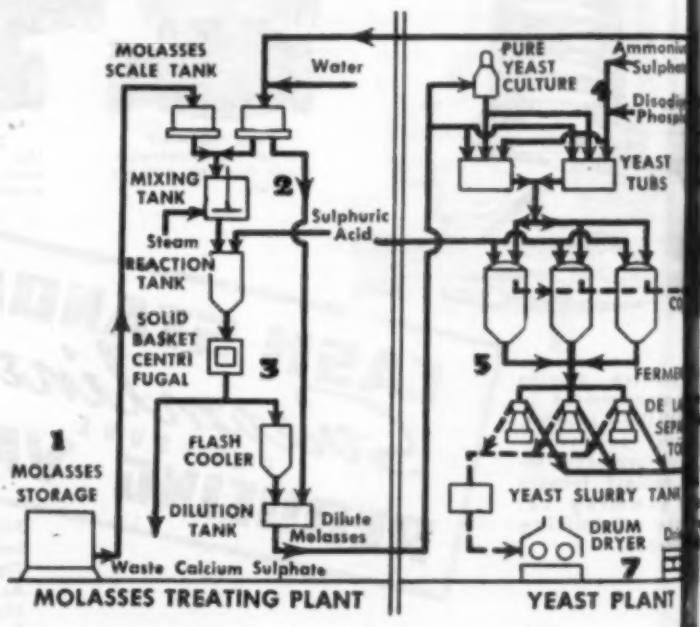

A Chem & Met FLOW SHEET

CHEMICAL & METALLURGICAL ENGINEERING
MAY, 1945
PAGES 142 to 145

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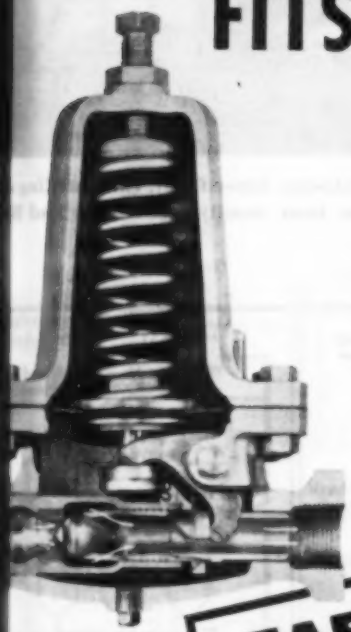

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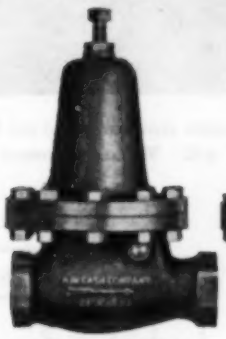

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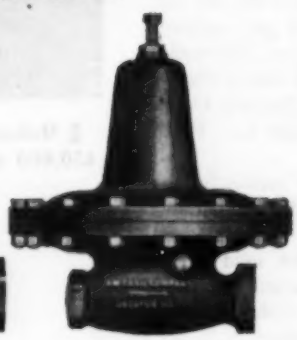

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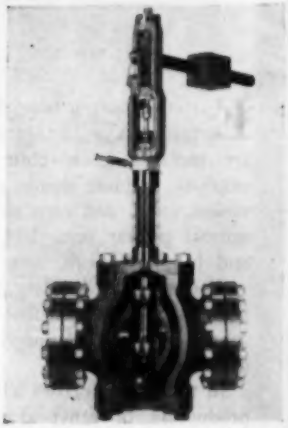

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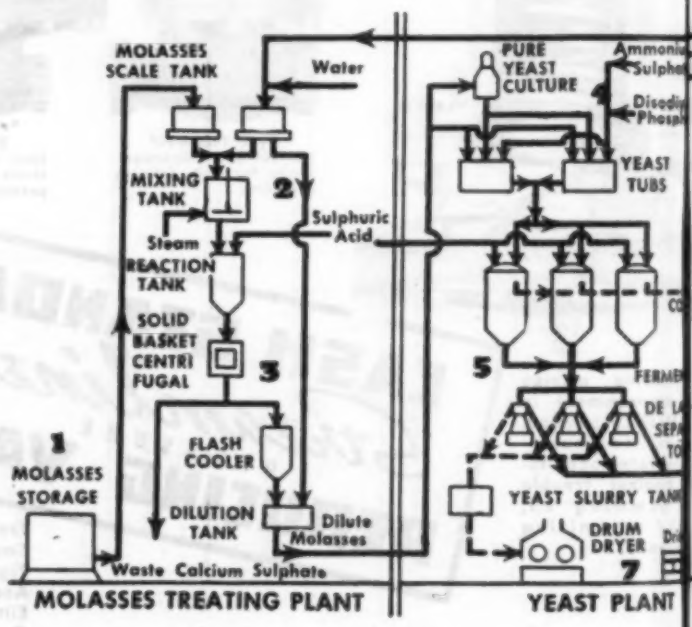
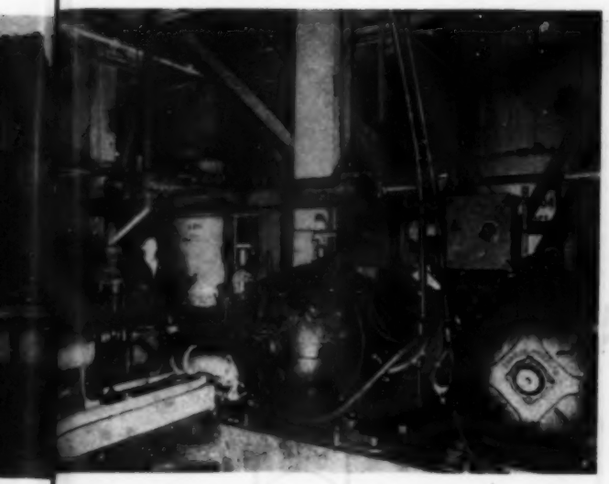
1 Molasses storage tanks on Delaware River front, each holding 450,000 gal. Molasses comes by boat, mostly from Cuba and



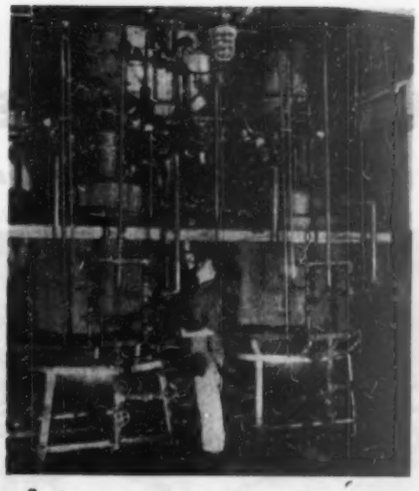
A Chem & Met FLOW SHEET

CHEMICAL & METALLURGICAL ENGINEERING
MAY, 1945
PAGES 142 to 145

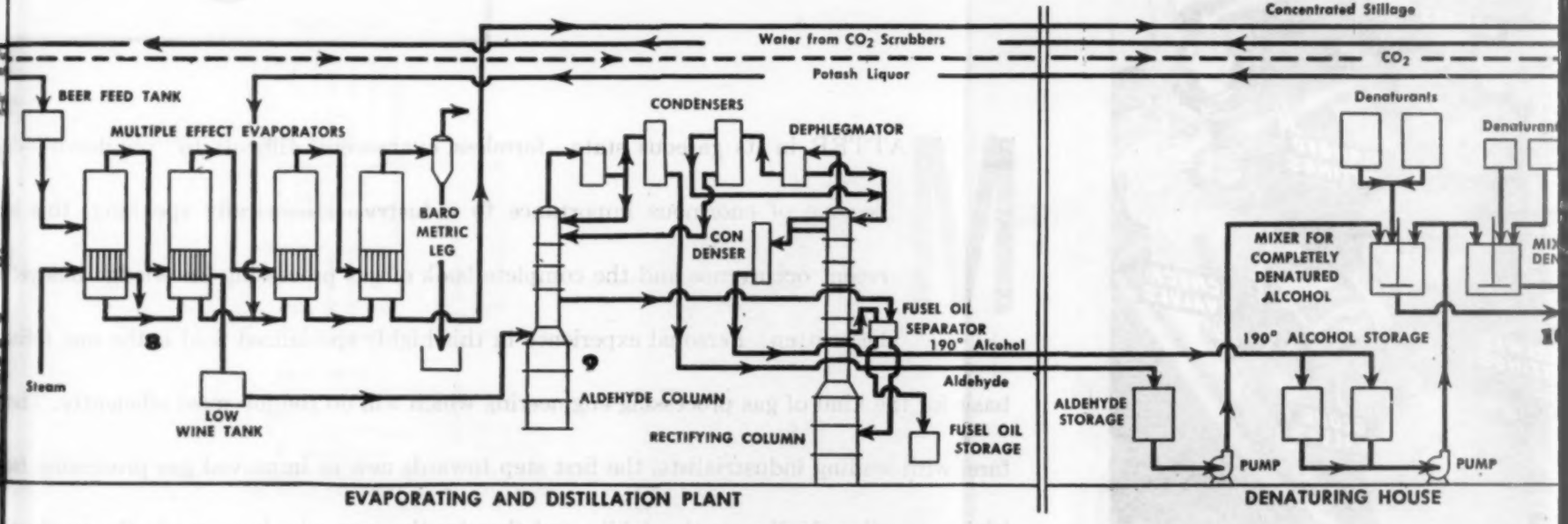


2 Three pairs of pumps transfer molasses to and from fermenters, then to evaporators. Motors are explosion-proof

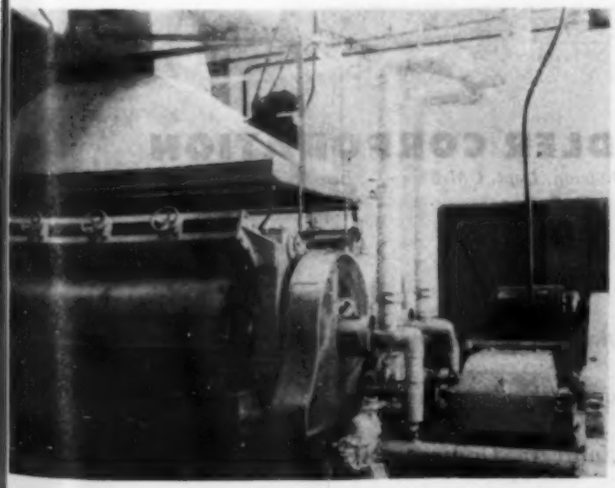
3 Solid-basket centrifugals which remove calcium sulphate precipitated by addition of sulphuric acid to diluted molasses



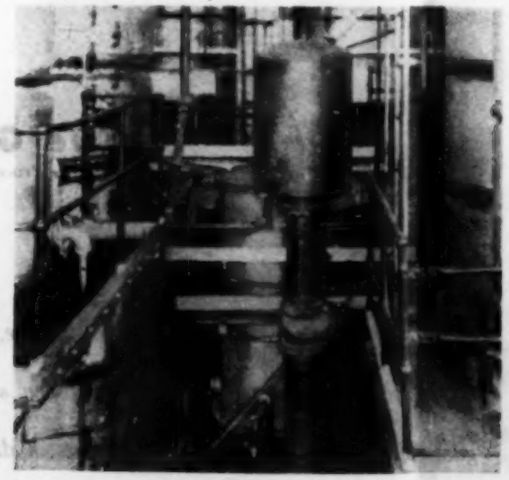
4 Pure yeast culture machines. Close temperature control is very important



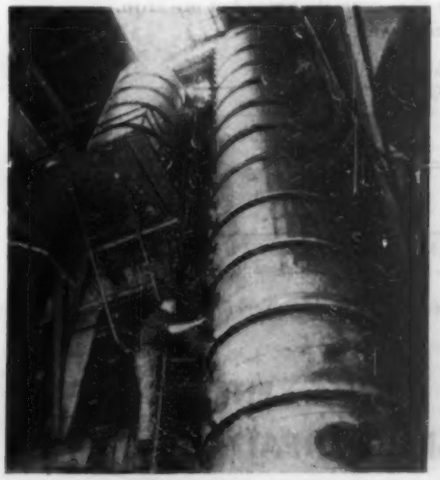
7 Drum dryer which follows wash tanks in yeast recovery system. Dried yeast is ready for packaging and the market

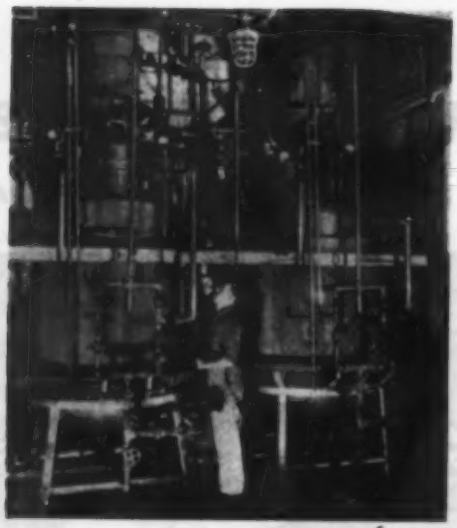


8 Multiple effect evaporators which de-alcoholize the yeast-free "beer" and concentrate the stillage

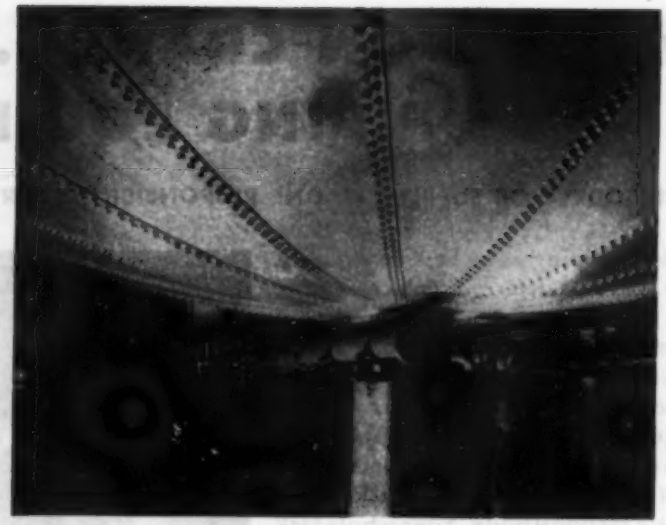


9 Aldehyde (left) and rectifying stills concentrate the alcohol, remove impurities

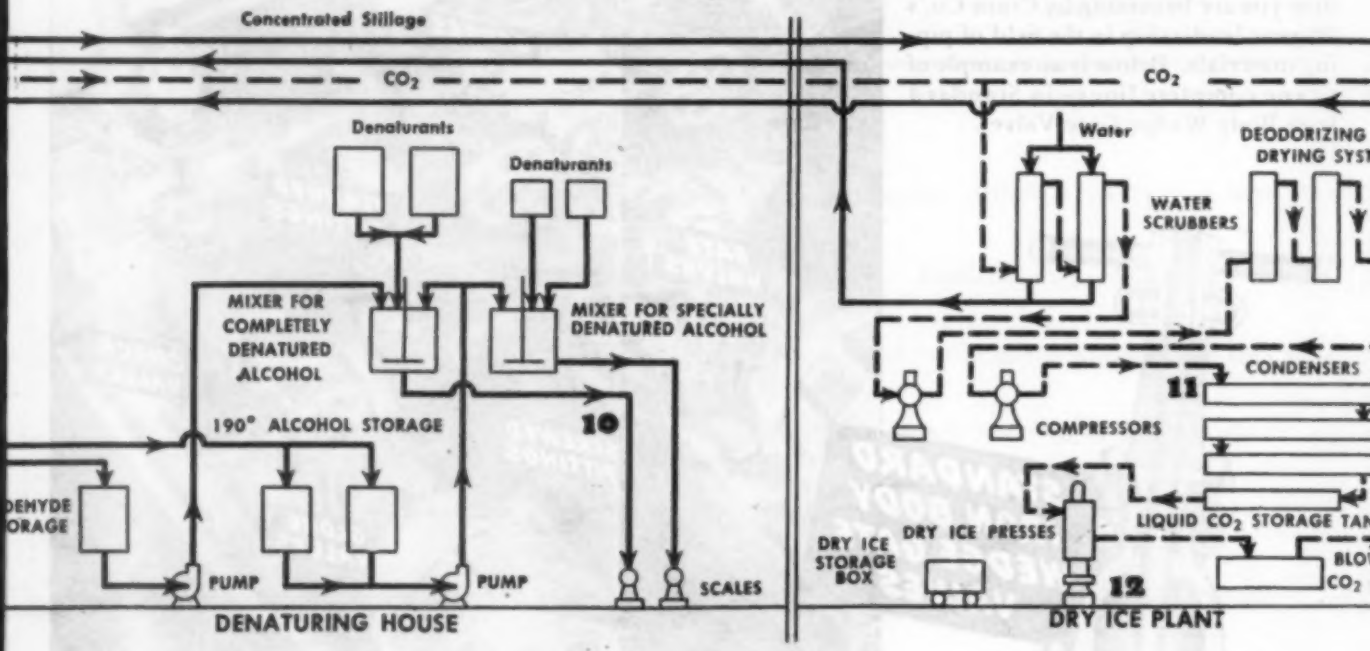




4 Pure yeast culture machines. Close temperature control is very important

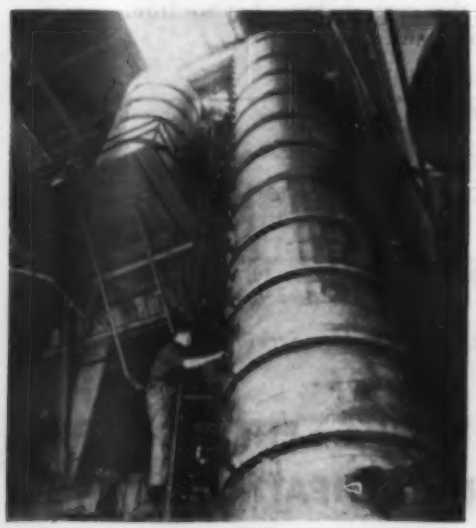


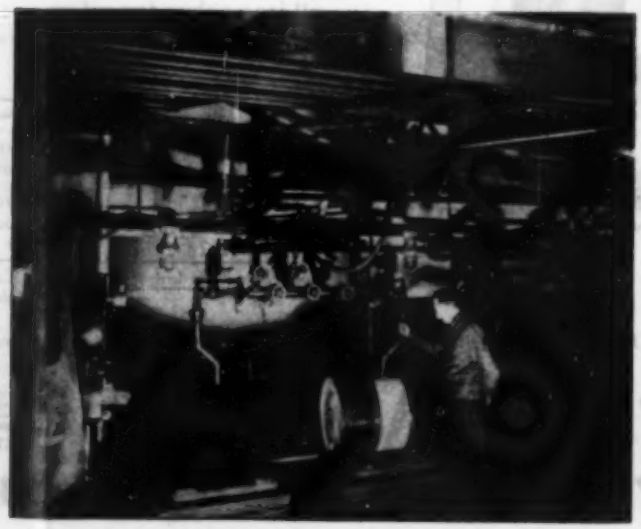
5 Bottom of 100,000-gal. fermenter. Fermentation takes 36-48 hr., yields "beer" with 6.5–8.5 percent alcohol by vol.

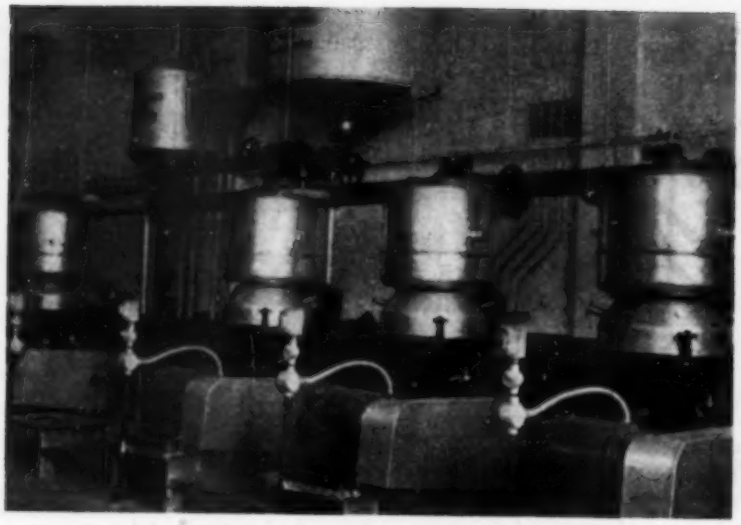


9 Aldehyde (left) and rectifying stills concentrate the alcohol, remove impurities

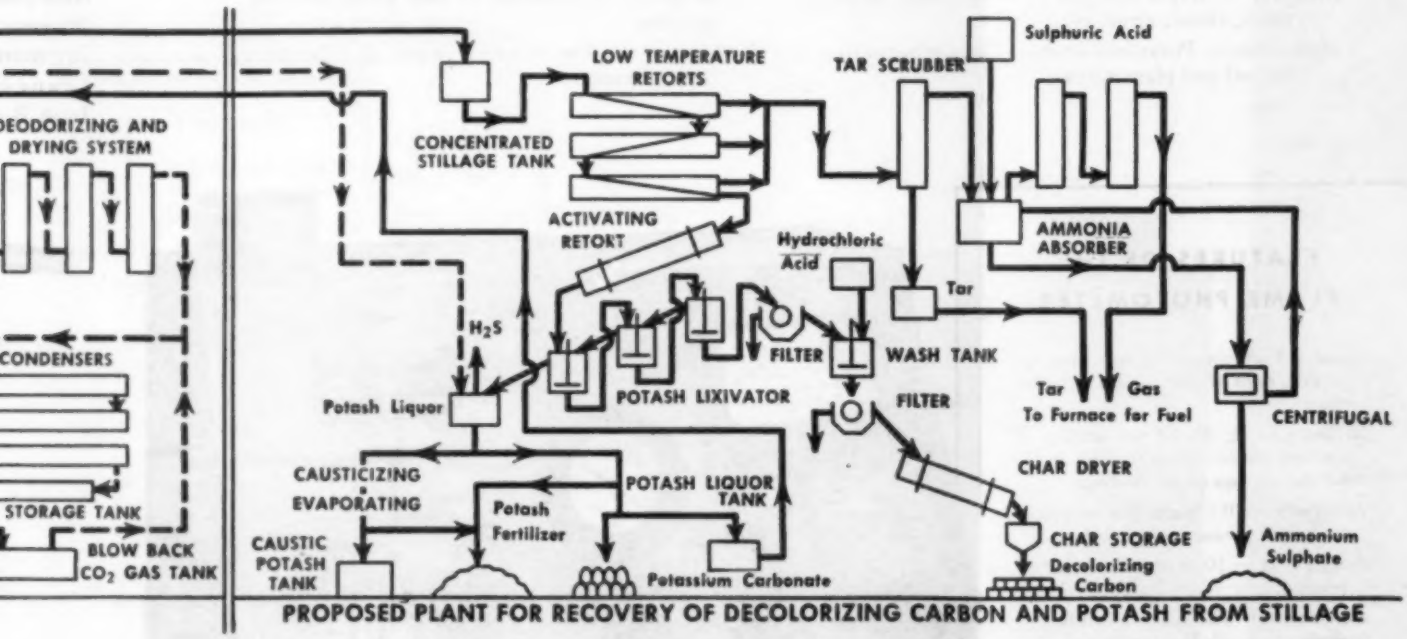
10 Barrel on scales being filled with denatured alcohol. Denaturing operation is under government supervision





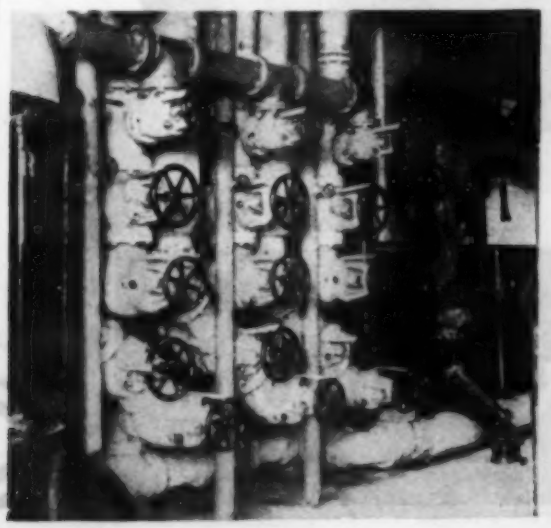


6 De Laval separators which remove yeast from "beer." This is only distillery in country recovering yeast from fermented mash



PROPOSED PLANT FOR RECOVERY OF DECOLORIZING CARBON AND POTASH FROM STILLAGE

11 Condenser coils which liquefy CO_2 in dry ice plant by means of pressure and refrigeration



12 Hydraulic presses into which liquid CO_2 is sprayed, forming dry "snow." Snow is compressed to solid cake under 150-ton pressure

Announcing

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Agriculture — Potassium analyses can now be routine for soil and plant survey.

Water Chemistry — Useful for water softening determination, resin bed exhaustion, boiler feed water analysis, etc.

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Chemical Processes — Wherever the alkaline content of initial, intermediate or final products is important.

Universities — For research work or laboratory demonstration.

FEATURES OF THE FLAME PHOTOMETER

Speed — Two minutes for individual determinations of sodium and of potassium.

Accuracy — ± 3% of the amount of element present in one reading, ± 1% for the average of ten readings.

Sensitivity — 0.1 parts per million of sodium or potassium in solution.

Sample Size — 10 cc of solution for a reading.

Interferences — The analysis can be made practically independent of the presence of other elements.

Photometer — Single self-contained unit, small, rugged, easily transportable.

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Personnel — Relatively untrained personnel can operate the flame photometer easily and accurately.

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ONE SOURCE OF SUPPLY • ONE RESPONSIBILITY FOR ALL PARTS • ONE STANDARD OF QUALITY

To keep piping at its best, to simplify and speed up deferred replacements—call on the Crane line. You choose from the world's greatest selection of piping materials—in brass, iron and steel. One source—your Crane Branch or Wholesaler—supplies on one order all your requirements. Every part is uniform in quality, backed by a single responsibility. Your whole task from ordering of parts to installing them is simplified—and at the same time you are benefiting by Crane Co.'s 90-year leadership in the field of piping materials. Below is an example of Crane complete lines—in Standard Iron Body Wedge Gate Valves.

Boiler control system for regulating dampers

SERVICE RECOMMENDATIONS: **Crane Standard Iron Body Wedge Gate Valves** with Brass trim are recommended for steam, water or oil lines; all-iron valves for oil, gas or fluids that corrode brass but not iron. Made in O.S.&Y. and Non-rising Stem patterns.

Working Pressures

Size of Valve	Screwed or flanged end valves		Hub end valves
	Saturated Steam	Cold water, oil or gas, non-shock	Cold water or gas, non-shock
2 to 12 in.	125 pounds	200 pounds	200 pounds
14 & 16 in.	125 pounds	150 pounds	150 pounds
18 to 24 in.	*	150 pounds	150 pounds

*For steam lines larger than 16-in., Crane 150 pound Cast Steel Gate Valves are recommended. (For sizes under 2 in., use Crane Clamp Gate Valves.)

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PLUMBING • HEATING • PUMPS

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NEW PRODUCTS AND MATERIALS

JAMES A. LEE, Managing Editor

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CASTING SEALANTS

DEVELOPMENT and production of a new series of casting sealants, now used in B-29 bombers and other military aircraft, has been made public by Monsanto Chemical Co., St. Louis, Mo. The material has been developed to meet urgent demand of aircraft manufacturers for materials to take the place of foreign-produced tung oil for impregnating magnesium and aluminum castings. Finely-machined, untreated castings made from aluminum or magnesium show a pronounced tendency to develop porosity. This does not affect their mechanical strength, but it does result in leakage of liquids and vapors in lubricating, cooling, and hydraulic systems.

A number of compounds, both inorganic and organic, have been used in this country and abroad for sealing of porous metal castings to prevent liquid and vapor leaks. These exhibit certain deficiencies in sealing efficiency and stability under operating conditions. The new material is reported to overcome these difficulties and provide maximum sealing effectiveness with full adaptability to sealing castings on a production line basis. The series of sealants developed for this purpose, and which Monsanto intends to continue in production after the war, are identified as being of the Thalid X100 series. These are special adaptations of a family of polyester type resins used in low-pressure lamination. Thalid X100 series resins, used as casting sealants, are thermosetting solutions, a mixture of base resin and styrene monomer. By varying the ratio of the two, the viscosity of the impregnating solution can be controlled to meet varying requirements arising from variation in the size of porosity in aluminum and magnesium. The solution is applied by positive or vacuum pressure impregnation. Following impregnation the castings are put through a heating cycle which thoroughly cures the resin to a slightly rubbery condition within the pores of the metal.

Parts may subsequently be machined, although the casting is usually fully machined before impregnation. The cured sealant is stable under high engine temperatures and has good resistance to lubricating oil, hydraulic fluids and coolants.

AIR-FOIL LACQUER

RELEASE of information concerning the new jet fighter plane, the P-80 "Shooting Star," makes possible the announcement of a proprietary air-foil pyroxylin lacquer developed especially for the P-80 by E. I. du Pont de Nemours & Co., Wilmington, Del. The lacquer is designed to provide ultra-smoothness of all external surfaces.

To reduce air resistance to a minimum, all external rivets are countersunk and aircraft type putty is used to fill all cracks. Over this a liberal coat of surfacer is applied and rubbed, sanded and polished. Finally, the air-foil lacquer topcoat is sprayed, buffed and rubbed to polished-glass smoothness.

A special thinner also had to be evolved to allow the extremely fast-drying lacquer to flow out to a smooth film. The lacquer must be laid down evenly so as to minimize buffing operations. Furthermore, while the film must be hard enough to be buffed and polished, it must also be flexible to withstand vibration at low temperatures (—70 deg. F.).

In addition to the smoothness of this light grey topcoat, exposure tests indicate it is one of the most durable ever developed for this purpose. The lacquer has good resistance to gasoline, hydraulic brake fluid and de-icing fluid. It has excellent acid resistance and water resistance, which minimizes the tendency to peel when wet at high speed. The general film properties of the lacquer are reported to exceed the requirements of the specifications covering gloss lacquers for military aircraft.

ULTRA-VIOLET ABSORBING PLASTIC

A SYNTHETIC azine which absorbs more than 99.9 percent of the ultra-violet radiations of the sun has been used in the manufacture of a plastic goggle lens by the Polaroid Corp., Cambridge, Mass. The chemically treated plastic is said to transmit as much light as a window pane and yet block all ultra-violet rays. Although many other ultra-violet absorbing compounds are known, the plastic is distinguished by the combination of stability, high transmission to visible light, high ultra-violet absorption, and non-fluorescence when ultra-violet light strikes it. The chemically treated plastics are employed not only as goggle lenses but also as filters in military visual instruments such as range finders and gun sights.

WATERPROOF COATING

A RECENTLY developed waterproof coating is now being marketed by Continental Asbestos and Refining Corp., New York, N. Y. It is used for protecting roofs, walls, and other surfaces exposed to the elements. This material, called Liquinoleum, is said to have about eight times the protective thickness of paint. It is resilient and elastic and thus is highly resistant to extremes of temperature. Even after long exposure it will not crack, blister, or "alligator."

It is claimed that Liquinoleum is unaffected by acid fumes or the effects of most chemicals. It does not crystallize on setting. Even flame from a blow torch will not cause it to catch fire, flow or run. No special labor is required to use Liquinoleum; it is readily applied to any surface with brush or trowel.

ENVELOPE ADHESIVE

A NON-CURLING, re-moistening gum for use on lightweight, air mail envelope stock has been developed for machine applications by the National Adhesives Div., National Starch Products, Inc., New York, N. Y. Envelope manufacturers working with this type of stock frequently experience difficulty due to the tendency of fast drying front seal gums to curl extremely lightweight papers, complicating both the machine operation and the subsequent packing of the envelopes.

Identified as Air Mail FS Gum, the product is said to possess an extremely light color, a high gloss, clean machining characteristics, and a responsive tack when remoistened. Its hygroscopicity is very low for a non-curling gum, so that the danger of blocking is minimized.

RESINS FOR PLASTICS

A NEW FAMILY of liquid resins, called Vibron, has been developed by the U. S. Rubber Co., New York, N. Y. The new materials, when combined with spun glass or other fabrics, are said to have a strength per pound equivalent to that of steel. Potential uses for Vibron resins are seen in the production of building materials for prefabricated houses, moisture-impervious furniture and luggage, artificial leather, upholstery fabrics, and packaging material.

The Vibrons are a polyester type resin and are thermosetting at atmospheric temperature and pressure, thus permitting the production of castings and laminated structures by simple methods and at contact or low pressure without need for heavy, high-pressure equipment. Resistance to cold flow and to permanent set are feature characteristics, and abrasion resistance is said to be sufficiently high to permit use of the

resins in making such items as transmission belts. Dyes, pigments and fillers are readily incorporated.

To illustrate the properties of Vibron resins, a typical member of the series, Vibron-103, may be described in some detail. Vibron-103 is a liquid resin which, in the presence of a catalyst (benzoyl peroxide), cures to an infusible, insoluble solid without giving off gaseous or volatile products. When mixed with the catalyst ready for use, it is a clear, nearly colorless (pale yellow) liquid with a sp. gr. of 1.15-1.16 and a viscosity of 2-5 poises. The catalyzed mixture is stable for several hours or even days, depending on the catalyst ratio used and the temperature of storage. For long storage, refrigeration is desirable.

During the cure of Vibron 103 several changes take place. The fluid resin becomes more and more viscous, then changes abruptly to a friable gel. When the reaction is about 80 percent complete, the resin becomes strong and flexible, and in the final stages of cure it decreases in flexibility and increases in strength, to the final state in which it is a very strong, only slightly flexible, clear, transparent solid. For experimental cures, one hour at 70 deg. C. followed by one hour at 120 deg. C. is recommended. Further tests will then indicate the best cycle for the problem at hand.

Properties of Vibron-103 Resin*

Sp. gravity	1.28
Vol. shrinkage on curing, %	9.4
Unnotched Izod impact strength, room temp., ft.-lb./sq. in.	10.3
Flexural strength, room temp., psi	17,000
Young's modulus, room temp., psi	240,000
Rockwell hardness, room temp.	M-80
Elongation at break, est. %	5-10
Refractive index	1.533
Electrical properties	
Volume resistivity, ohm-cm.	6×10^{15}
Dielectric constant (60 cycles)	5.1
Loss factor (60 cycles)	0.17
Dielectric strength (0.005-in. sample), v./mil	2,000
Chemical resistance	Percent absorption
(ASTM) 1 week immersion, room temp.)	
Distilled water	1.05
30% Sulphuric acid	0.45
3% Sulphuric acid	0.87
10% Nitric acid	0.95
10% Sodium hydroxide	†2.11
1% Sodium hydroxide	0.87
95% Ethyl alcohol	†2.03
Acetone	†9.5
Carbon tetrachloride	0.20
Gasoline	Nil

* Characteristic differences in physical properties, such as hardness, flexibility and abrasion resistance in finished products, can be obtained by choosing from the different types of Vibron resins. † Eventually cracks.

SODIUM TETRAPHOSPHATE

FOR FOUR or five years, sodium tetraphosphate ($Na_6 P_4 O_{13}$) has been distributed to the textile, food and laundry industries by the Rumford Chemical Works, Rumford, R. I., under the name Quadrafos. It is used as a detergent, water conditioner, disprsing agent, and dye assistant.

Heretofore, Quadrofos has been in granular form. It is now available in a new form—Quadrafos Beads, which are smoothly rounded spheroids about ¼-in. dia., having a crystal clear, glass-like structure.

Advantages claimed for the bead-form are in regard to greater safety and ease of handling in making up stock solutions. The beads flow more freely, dissolve rapidly, will not stick or pack, contain no dusty fines. In addition, Quadrafos Beads are packaged in special containers which simplify the preparation of stock solutions.

ACID INHIBITOR

AN ORGANIC acid liquid inhibitor in powdered form, designated Pennsalt PM-40, has recently been developed by the Pennsylvania Salt Mfg. Co., Philadelphia, Pa. This material is highly stable and is completely soluble in pickling baths of either hydrochloric or sulphuric acids. It contains 100 percent acid ingredients and is highly effective at such low concentrations as 0.02 to 0.10 percent by weight of pickling bath.

Concentrations may be varied to suit plant conditions, production rate, and quality of surface desired.

Due to high base metal protection, the acid is consumed principally in scale and rust removal with the result that the useful life of the bath is prolonged. Pennsalt PM-40 can be used in acid pickling baths prior to electroplating, galvanizing and enameling, since it is free-rinsing and minimizes hydrogen absorption. It is packaged in drums of 25, 100 and 200 lb. and is available in commercial quantities for bulk pickling operations.

DIRECTIONALLY RESILIENT FABRIC

A NEW TEXTILE fabric featuring directional resiliency is now being manufactured experimentally by Kendall Mills, Walpole, Mass. It should be explained that "directional resiliency" means that the fabric, when folded, is springy in one direction, limp in the other. This property is produced by using resin-impregnated yarn as filling and unimpregnated yarn as warp.

The fabric, trade-named Perx, was developed for use as inner reinforcing in men's and women's suit coats and overcoats. Perx is sanforized with a residual shrinkage of not more than 1 percent in both warp and filling. It is claimed that yarns do not pull out nor become brittle and break, that repeated washings do not destroy the "hand" and that filling yarns are color-fast to dry cleaning and laundering.

LIQUID INSULATION

ACCORDING to a recent announcement, U. S. Industrial Chemicals, Inc., New York, N. Y., has developed a water-repellent, insulating liquid, called PiB, which appears to give electrical systems in automotive engines virtual immunity to moisture, wet weather, and many acids. It is said that after PiB has been brushed or sprayed on spark plugs, wiring, distributor and battery, an automobile engine will keep running even though the hood is lifted and water doused on the engine with a hose. Or if a motor or engine has already been "drowned out," the application of PiB will get it running again in short order.

The product is described as a liquid with powerful penetrating action and high resistance to water, ordinary acids, oils, and greases. Its viscosity is low, so that it will flow freely into inaccessible crannies. Water repellent properties coupled with strong wetting action enable it to undermine a displace water which may be present in wiring system or on insulating surfa PiB has a dielectric strength of 4,000 v. mil, and under normal conditions, its p tective qualities last for a minimum six months.

The most important current use is protecting ignition systems of Americ amphibious war machinery. Its potent field, however, extends through facto machinery, trucks, buses, passenger c marine engines, and farm machinery. will be used to waterproof ignition syste to prevent corrosion and current losse batteries, and to re-insulate cracked dried out wiring.

FLAME RESISTANT PLASTIC

A CELLULOSE acetate plastic has be announced by the Celanese Plastics Co New York, N. Y. It is known as the L marith-CA series and was developed o inally for cable grommets for ship h compartments. The new materials are s to offer a combination of properties hitherto found in one plastic. These pr erties are: high resistance to combined he and humidity, toughness, colorability moldability by the injection process. Th are odorless, do not promote corrosio and their resistance to cold flow is abo one-third higher than that of other cel lose plastics. Flame resistance can b added without detracting from its oth qualities—in fact flexural and tens strength are said to be increased.

CYCLOHEXYLAMINE

CYCLOHEXYLAMINE (also called hex hydroaniline) and the companion produc dicyclohexylamine, have been known f over 50 yr. and have found a number o applications. But it is thought that th chemicals' potential usefulness far exceed present uses, and that commercial produ tion, recently announced by Monsan Chemical Co., St. Louis, Mo., will be fo lowed by the discovery of many new i dustrial applications.

Cyclohexylamine is currently a corrosio inhibitor, a paint film solvent, an emulsify ing agent, and a compound from which dyestuffs are derived. There are prospect for its use in the manufacture of plasticiz ers, insecticides, chemical manufactur and synthetic resins.

Dicyclohexylamine is similar but is em ployed by the petroleum industry as a extreme pressure additive and in the manu facture of cutting oils.

Cyclohexylamine is a strong base. It forms salts with all acids, including carbon dioxide which is absorbed rapidly from the air. It reacts with long-chain fatty acids to form soaps. The nitrogen atom is ex tremely reactive and will combine readily with organic compounds containing an ac tive halogen atom, with acid anhydrides, or with alkylene oxides to form the cor responding N-substituted cyclohexylamine. One or both hydrogen atoms on the nitrogen may be replaced in this manner by alkyl, aralkyl, acyl, or alkylol groups. Cyclo hexylamine reacts with aldehydes similarly to aniline.

Cyclohexylamine is completely miscible with water and with all common organic solvents. On distillation in the presence

an excellent plasticizer available now

Monsanto Ortho-Nitrodiphenyl has amazing versatility when used as a plasticizer.

It can be used alone or in conjunction with other plasticizers and is applicable to the entire range of synthetic resins from the cellulose esters and ethers through the vinyls and vinyl copolymers.

It is compatible with alkyds and some synthetic rubbers.

Why not look into the possibilities of Monsanto Ortho-Nitrodiphenyl? You may find it to be your solution to the problem caused by hard-to-get plasticizers. Complete technical data and samples will be sent promptly upon request. Please use the coupon below, contact the nearest Monsanto office or write: MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1700 South Second Street, St. Louis 4, Missouri. District Offices: New York, Chicago, Boston, Detroit, Charlotte, Birmingham, Los Angeles, San Francisco, Seattle, Montreal, Toronto.

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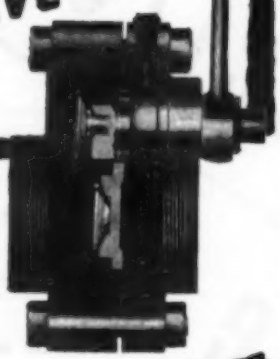
better than hand-lapped

A SELF-LAPPED VALVE SEAL!



It's true . . . the discs and seats on EVERLASTING valves *are* hand-lapped to secure the drop-tight seal when the valves are built. But it's the repeated self-grinding, self-polishing, SELF-LAPPING of the disc on the seat—every time this valve is used—that maintains the famous EVERLASTING drop-tight seal . . . *without maintenance!*

WITHOUT MAINTENANCE

This valve disc does not merely slide open and closed, as in the usual gate valve. This disc actually *rotates* within the disc-arm as it moves across the seat . . . SELF-LAPPING these sealing faces to microscopic precision. And the disc travels in constant contact with, and on, the seat table—they're never separated—so no grit or other substance can lodge between these sealing faces. The EVERLASTING drop-tight seal truly *improves with use!*

IMPROVES WITH USE

Changes of temperature cannot cause this valve to bind, because *all parts* function in a parallel plane . . . are free to self-compensate any expansion or contraction of individual parts. The disc, like all other internal parts, cannot become loose and choke the straight-through flow. And, since there is absolutely no wedging action in this valve—*it cannot stick!*

CANNOT STICK

A DEPENDABLE valve, well worth your learning more about—so why not write today for our Bulletin?

EVERLASTING VALVE CO., 49 Fisk St., Jersey City 5, N. J.

Everlasting Valves

for everlasting protection

of water, it forms an azeotropic mixture boiling at 96.4 deg. C. at 760 mm. and containing 44.2 percent cyclohexylamine by weight.

Dicyclohexylamine is a strong base, being slightly more basic than cyclohexylamine. The reactions of dicyclohexylamine are similar to those of cyclohexylamine except that only monosubstitution products can be formed. It forms salts with all acids and soaps with fatty acids. N-substituted derivatives can be formed as with cyclohexylamine. Dicyclohexylamine differs from cyclohexylamine in that it forms crystalline hydrates and alcoholates at low temperatures.

Dicyclohexylamine is only slightly soluble in water, but is soluble in all common organic solvents and miscible with cyclohexylamine. It does not form an azeotropic mixture on distillation with water.

Properties of Cyclohexylamine

Appearance	Water-white liquid
Odor	Strong, fishy, amine-like
Sp. gravity, 25/25 deg. C	0.8647
Boiling pt., deg. C.	134.5
Flash pt., deg. F.	90
Fire pt. (sustained combustion), deg. F.	95
Refractive index, 25 deg. C.	1.4565
Crystallizing pt., deg. C.	−17.7

Properties of Dicyclohexylamine

Appearance	Water-white liquid
Odor	Faint, resembling cyclohexylamine
Sp. gravity, 25/25 deg. C.	0.9104
Boiling pt., deg. C.	255.8
Flash pt., deg. F.	210
Fire pt. (sustained combustion), deg. F.	230
Refractive index, 25 deg. C.	1.4823
Crystallizing pt., deg. C.	−0.1

OIL WELL SEALING

A RESINOUS compound for the sealing of oil wells has lately been developed by the Wilmington Chemical Corp., New York, in collaboration with the Synvar Corp., Wilmington, Del. The product, known as Synvar Oil Well Sealing Compound, provides a water-and-oil-resistant seal and forms an integral and uniform structure with rock formation and pipe. A minimum of shrinkage is assured and the compound can be used at any practical temperature. It is applied in separate components which are combined just before use, the proportions of the different components being adjusted to existing well conditions.

RUST PREVENTIVE

RADIATORS, water jackets and cooling systems can be kept clean and free of rust by using their new preventive compound. Gibraltar Rad-Treat, says the Hood Refining Co., Greensburg, Pa. The compound is not a solvent but it emulsifies quickly with water or any anti-freeze and does not later settle out.

Claim is also made that Gibraltar Rad-Treat will lubricate packing glands in pumps, at the same time preventing shrinking and glazing of packing. It will not attack rubber, nor is it harmful to any metal—on the contrary, recommendation is being made that Rad-Treat be used to neutralize any acid condition which might have been left in a radiator which has been flushed with caustic solutions. Approximately 8 oz. of the product, a compounded oil and rust preventive, are added to each 5 gal. of water or anti-freeze.

CHEMICAL ENGINEERING NEWS

PRINCETON STARTS COURSE IN PLASTICS

INSTITUTION by Princeton University of a program of instruction and research in plastics has been announced by Prof. Kenneth H. Condit, dean of the Princeton School of Engineering. He said the program has the two-fold purpose of meeting the demand in industry for men equipped with scientific or engineering training supplemented by a comprehensive background in plastics and of conducting fundamental research in plastics and their application.

Sponsored by the School of Engineering, the program is a cooperative enterprise of the department of mechanical, chemical and electrical engineering and of chemistry and physics. It has the assistance of an advisory committee of 16 industrialists headed by George K. Schribner, president of the Boonton Molding Co. Industrial concerns also are lending support through the donation of equipment for the newly-converted plastics laboratory building and the gift of funds.

B. F. GOODRICH CO. FORMS CHEMICAL COMPANY

ESTABLISHMENT of B. F. Goodrich Chemical Co., a division of The B. F. Goodrich Co., was announced last month. B. F. Goodrich Chemical Co., is engaged in the manufacture and sale of the company's line of Geon vinyl resins, chemicals, and synthetic and reclaim rubbers. William S. Richardson, with Goodrich since 1926, is president of the company.

Mr. Richardson has held executive positions with B. F. Goodrich and is vice president of Hycar Chemical Co. organized in 1940 by Goodrich and Phillips Petroleum Co. to manufacture and sell synthetic rubbers. This company was the first and is the largest private commercial producer of butadiene-type synthetic rubber in the United States.

B. F. Goodrich Chemical Company offices and service laboratories are located in the Rose Bldg. Cleveland.

LONDON CLUB ENTERTAINS AMERICAN CHEMICAL MEN

ON THE evening of April 5, the Chemical Club of London, England, held a soiree and cocktail buffet so as to give leaders in the British chemical industry an opportunity to meet Sidney D. Kirkpatrick, editor of *Chem. & Met.* and other members of the American chemical industry who happened to be in London on that date. T. W. Jones, secretary of the club acted as host and he had on hand an expert cartoonist and sketch artist who made "charactitures" of the guests, some of these drawings probably will appear in an early issue of his publication, the *Industrial Chemist*.

In addition to Mr. Kirkpatrick, Americans present included Gaston Du Bois and Frank J. Curtis of Monsanto, W. S. Calcott, of DuPont, M. F. Fogler of Allied Chemical, and L. V. Burton, editor of *Food Industries*. Military men present included Col. H. B. Bramlet, C. W. S. Chief Chemical Officer, United Kingdom; Lieut. Col. P. R. Tarr, Chief of Chemical Intellegence; and Lieut. Robert S. Day of the combat engineers.

Among the Britishers were C. S. Robinson of Imperial Chemicals; C. S. Garland, M. P.; J. Davidson Pratt, K. B. E.; Herbert Cremer; Percy Parrish; Louis Jordon; Kent Jones; Howard Brownlee; F. A. Greene, president of the Institution of Chemical Engineers; and Bill Dixon of Wallace & Tiernan, Ltd.

NEOPRENE UNIT COMPLETED AT LOUISVILLE

COMPLETION of a new unit at the Du Pont-operated neoprene plant in Louisville was announced at the end of April by E. W. Thompson, plant manager, who said the expanded facilities will step up production of neoprene by approximately 26 percent to an annual volume of 60,000 tons. The new addition, constructed and equipped at a cost of $7,000,000, is the fifth of a series of units which have been rushed to completion to meet the rapidly increasing demand for neoprene. Because of the large amount of chlorine required in neoprene manufacture, the Louisville plant houses the world's largest hydrochloric acid unit which consumes approximately 10 million pounds of salt per month in five furnaces to produce about 17 million pounds of 35 percent acid.

NATIONAL SAFETY COUNCIL GRANTS SUBSIDIES

FOUR colleges have been granted subsidies by the National Safety Council to institute safety engineering education as an integral part of their basic engineering training. The colleges, selected on a basis of geographic location, are the Georgia School of Technology, University of California, Illinois Institute of Technology, and New York University. Chancellor Harry Woodburn Chase announced on May 1 that the subsidy of $8,000 granted New York University will be used to establish a professorship in safety engineering and to reorganize and re-equip all engineering laboratories and shops so that they will incorporate true safety practices.

CEREAL CHEMISTS HONOR DR. JOHN C. BAKER

DUE TO the cancellation of the annual meeting of the American Association of Cereal Chemists which was originally scheduled for Toronto, Canada, the New York Section of the Association sponsored a special dinner meeting in the Grand Ballroom of the Hotel New Yorker on May 15, at which the Thomas Burr Osborne Medal was awarded to Dr. John C. Baker of Wallace & Tiernan Co., Inc.

MCA PREPARES MANUAL FOR LABELLING CHEMICALS

A GUIDE for the preparation of labels for hazardous chemicals has recently been completed for distribution as manual L-1 of Manufacturing Chemists' Association. This is a pioneer effort of MCA to give a broad classification of hazards and definitions of terms by which they can clearly and correctly be described. Those using the manual will find it virtually a code of good label practice. The manual has been prepared with the cooperation of a number of government agencies. It is expected that its general adoption by industry will follow almost automatically.

HERCULES COMPLETES UNIT FOR LAMINATE SHEETS

THE first complete unit for the production of cellulose-derivative laminate sheets is now in operation at Hercules Powder Co.'s plant in Parlin, N. J. Because of the shortage of textiles, paper, and other laminating stock, the company, for the present, will be able to serve only fabricators, who are manufacturing essential war products. The thermoplastic laminating facilities include a multi-opening press which will manufacture 50 x 50 in. flat sheets.

This program has been undertaken by Hercules to aid the plastics industry in studying production costs and processes and to study new markets for laminates.

JERGENS BUYS SITE FOR POSTWAR PLANT

LATE in April, it was announced that the Andrew Jergens Co. of Cincinnati had purchased 67 acres of land on Reading Road outside of Cincinnati and had drawn up plans to use the property for the erection in the postwar era, of a new soap and cosmetics plant modelled after the one which the company operates in Belleville, N. J. The plant on Spring Grove Ave., Cincinnati, now in operation will be continued in production until the new plant has been completed.

ELECTROCHEMICAL SOCIETY ELECTS OFFICERS

THE 44th annual meeting of The Electrochemical Society, Inc., and the annual meeting of the board of directors of the Society which were to have been held in Atlantic City in conjunction with the 87th Congress of the Society were held in New York on April 27. After the business sessions, officers for the ensuing year were elected as follows: president, William R. Veazey, director of the research laboratories, Dow Chemical Co., Midland, Mich.; vice president, James A. Lee, *Chemical & Metallurgical Engineering*, New York; treasurer, W. W. Winship, Thermal Syndicate, Ltd., New York; and secretary, Prof. Colin G. Fink, Columbia University, New York.

A Low Cost GRIGNARD REAGENT

$$CH_3Cl + Mg \xrightarrow[dry]{ether} CH_3MgCl$$

with ANSUL Methyl Chloride

YIELDS—excellent, better than 90%.

REACTION—Proceeds smoothly, rapidly, and is easily controlled.

APPARATUS—simple and inexpensive.

ANSUL CH_3Cl—Now a low cost chemical due to greatly expanded production facilities.

MAGNESIUM—readily available and now relatively inexpensive.

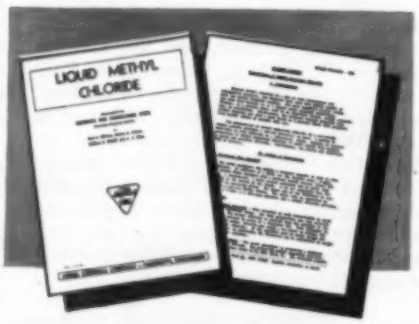
CONCLUSIONS—excellent yield, smooth reaction, inexpensive methyl chloride and magnesium... make a Low Cost Grignard Reagent.

LIQUID Methyl Chloride ANSUL*

PHYSICAL PROPERTIES

Chemical formula	CH_3Cl
Molecular weight	50.491
Color (gas or liquid)	Colorless
Odor	Ethereal, non-irritating
Melting point	−144° F. (−97.6° C.)
Boiling point	−10.65° F. (−23.7° C.)
Critical temperature	289.6° F. (143.1° C.)
Critical pressure	969.2 lbs. per sq. in. abs.
Solubility	Methyl chloride in water—3 to 4 volumes methyl chloride vapor in 1 volume of water at ordinary temperatures and atmospheric pressure—methyl chloride in alcohol—readily soluble
Specific gravity of liquid	.909

*REG. U. S. PAT. OFF.



Send for Bulletin No. 900, "Preparing Methyl Grignard Reagent with Methyl Chloride"...and for "Liquid Methyl Chloride"—a treatise on the properties and general handling of Ansul Methyl Chloride.

ANSUL CHEMICAL COMPANY, MARINETTE, WIS.
Eastern Office: 60 E. 42nd St., New York City

AMERICAN CERAMIC SOCIETY HOLDS ANNUAL MEETING

THE forty-seventh annual meeting of t American Ceramic Society was held Buffalo on April 16 under the diffic conditions imposed by the war. Only members from outside the Buffalo a were permitted to attend but membe of the Upstate New York Section attend in sufficient numbers to make up a quor for the transaction of business. Edw H. Fritz in his address as retiring pre dent, stressed the need for research wo to keep the ceramic industry ahead the times. He suggested that a fund raised to encourage the study of fund mental problems of the clay and silic industries. He also recommended that t society employ a technical secretary coordinate the development work of t members and to assist in organizing s search projects. Clarence S. Ross, ch of the Section of Petrology, United Sta Geological Survey, gave the Edward Ort Jr., Fellow Lecture.

Officers elected for the ensuing ye were: president, C. Forrest Tefft, presid Claycraft Co., Columbus; vice presid J. Edward Hansen, director of servic Ferro Enamel Corp., Cleveland; treasur John D. Sullivan, assistant to the direct Battelle Memorial Institute, Columbu Ross C. Purdy of Columbus is general se retary and editor, a position he has he for the last 25 years.

NEW CONSTRUCTION PROGRAM FOR SHAWINIGAN

ANNOUNCEMENT by James Wilson, pre dent of The Shawinigan Water & Pow Co. of Canada reveals that the 1945 co struction program for Shawinigan, its su sidiary and associated companies, will i volve capital expenditures approximati $7,000,000. The parent company has im provements under way for the year whic will require approximately $2,800,000 connection with power plants, generati equipment, rural line extensions and su station enlargements. Similar expenditur for Quebec Power are estimated at $1,680,000. Projected extensions and improv ments to plants at Shawinigan Chemica and its associated companies at Shawinigan Falls will involve expenditure of approx mately $2,800,000. The program include pilot plants for new products which hav been developed in the research laboratories and general improvements in carbide plant and certain existing chemical processes. Construction has already commenced on a plant for the compounding of Vinylit resin.

CHICAGO DRUG & CHEMICAL ASS'N ELECTS OFFICERS

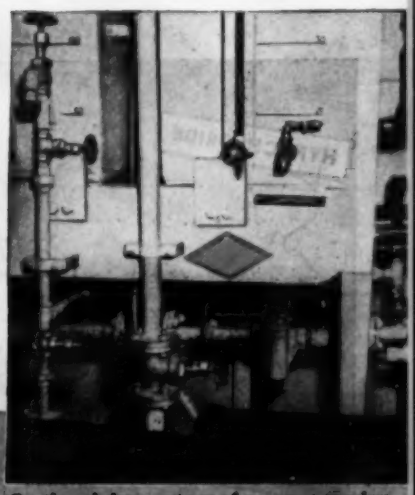
AT ITS forty-fifth annual meeting held recently in the Drake Hotel, Chicago, the Chicago Drug & Chemical Association elected Harry E. Dunning of Albert Ver ley & Co., president for the current year. Other newly-elected officers are: vice presi dent, Dale F. Ruedig, Eli Lilly & Co.; secretary, John L. Thomas, Joseph Turner & Co.; treasurer, Wilson I. Doan, Dow Chemical Co.

America's Fighting Men find "DIAMONDS" along the vital "fluid highway" of their mammoth war machine...

On a storage tank in the South Pacific.

At oil terminal docks throughout the wo

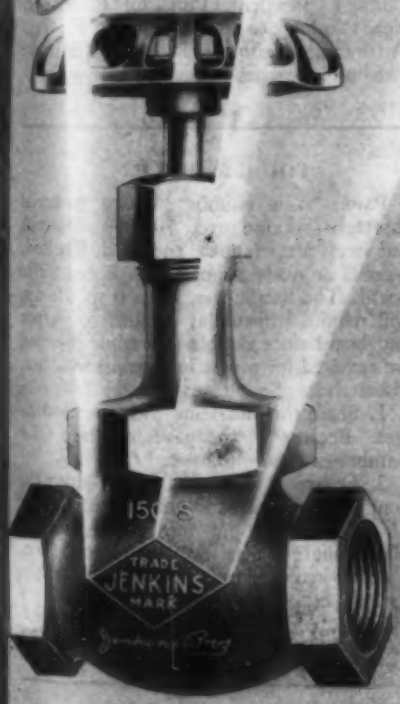
In the engine room of an LCI.



On the piping system of a cargo carrier.

TRADE JENKINS MARK

Jenkins Bros



American land, sea, and sky forces find the famous Jenkins Diamond trade mark wherever they serve, afloat or ashore, on hundreds of thousands of Jenkins Valves that control the "fluid highways" so essential to the steady march toward victory.

To these men, faced with stupendous tasks of moving rivers of "fighting fluids" and with operating equipment under the worst conditions imaginable, the Jenkins Diamond means dependable valve performance – a quality far more precious to them than bushels of real diamonds.

Wherever the American flag flies throughout the world, new millions of men are learning what valve-wise piping specialists have known for more than 80 years . . . that the Jenkins Diamond is the mark of *trustworthy* valves. It will remain our pledge of superlative quality, as long as Jenkins Valves are made.

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta, Boston, Philadelphia, Chicago, San Francisco. Jenkins Bros., Ltd., Montreal, London.

Look for the famous JENKINS DIAMOND-SIGNATURE TRADE MARK, and be sure of Trustworthy Valves

Jenkins has earned repeated Army-Navy and Maritime Flag awards by increasing production tremendously to meet endless war needs . . . but no slightest sacrifice has been made of Jenkins standards in materials, design, or workmanship.

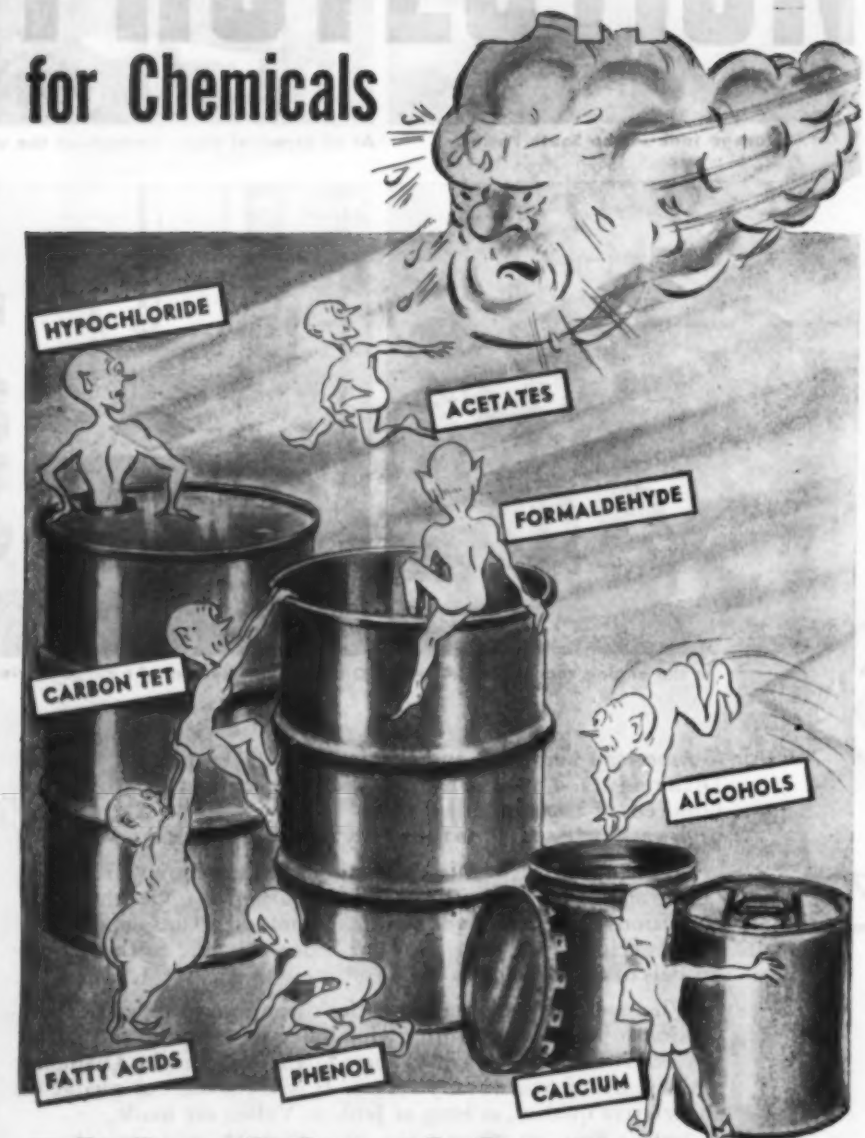
JENKINS VALVES

SINCE 1864

For every Industrial, Engineering, Marine and Commercial Service . . . In Bronze, Iron, Cast Steel and Corrosion-resisting Alloys . . . 125 to 600 lbs. pressure

Sold Through Reliable Industrial Distributors Everywhere

PROTECTION
for Chemicals



Inland Steel Containers

. . . safest, sturdiest, and most convenient shipping containers for chemicals — withstand rough handling, no leakage, no spoilage; dampness and fumes do not penetrate the steel container.

Steri Seald lined drums and pails provide complete protection for chemicals sensitive to contamination. They are available in a wide variety of sizes and styles best suited to the product. Convenient openings make filling easy and airtight resealing after opening practical.

INLAND STEEL CONTAINER CO.
Container Specialists
6532 S. MENARD AVE., CHICAGO 38, ILLINOIS
PLANTS AT: CHICAGO • NEW ORLEANS • JERSEY CITY

METAL CHEMICALS DIVISION FORMED BY VANADIUM CORP.

Announcement has been made by J. R. Van Fleet, president of United States Vanadium Corp., a Unit of Union Carbide and Carbon Corp., of the formation of a new division to be known as the Metal Chemicals Division. This division will manufacture and market inorganic compounds of certain metals including tungsten, molybdenum, vanadium and others in the industrial field.

J. A. Holladay has been elected a vice-president of United States Vanadium Corp. and has assumed charge of this new division. Production and sales will be under the direction of M. J. Gailey. Mr. Holladay's headquarters are in the main offices in New York. Mr. Gailey is located in Niagara Falls.

STREAM POLLUTION STUDY AT APPLETON, WIS.

The National Council for Stream Improvement of the Pulp, Paper and Paperboard Industries, Inc., has established a project at the Institute of Paper Chemistry, Appleton, Wis. This project will involve aquatic biology and will be under the immediate supervision of Dr. Willis Van Horn. Problems involving the effect of various types of mill wastes on fish life will be studied and means for preventing damage to fish will be developed. Experimental work will be carried on at the Institute and at mills where problems exist. A number of mills are carrying on similar work and most of these projects will be coordinated with the Institute's work through the Council.

INSTRUMENT SOCIETIES FORM NATIONAL GROUP

Representatives of 15 separate instrument societies met in Pittsburgh on April 28 and formed a new national group to be known as the Instrument Society of America. Protem officers chosen for the new organization are: Albert F. Sperry, Chicago, president; Prof. C. F. Kayan, New York, vice president; C. E. Fry, Pittsburgh, treasurer; Richard Rimbach, Pittsburgh, executive secretary.

YOU CAN HELP

Paper is a Number 1 war material shortage—because over 700,000 different war items are wrapped, packaged, labelled, tagged, or made from paper or container board. The Pacific war, when it speeds up, will require stupendous amounts of paper and board since double and triple packing are required for protection against weather, insects, etc. So please:

1. Share this magazine with your associates. Because of the paper shortage, the number of copies is limited.

2. Organize for a continuous drive in your office and plant to collect waste paper of any kind to put into paper salvage. Clean out old files, dead correspondence, obsolete records, useless display materials, cartons, etc.

DO THIS EXTRA BIT TO HELP

Looking for ways to improve your Product?

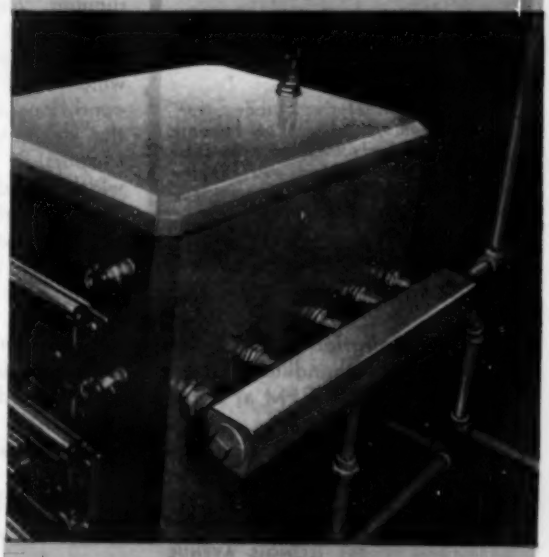
Try *American* FLEXIBLE METAL HOSE and TUBING

FLEXIBLE EXTENSION FOR INHALATOR

Through use of American Flexible Metal Tubing on this medical appliance, the vapor stream is directed as desired without moving the whole unit.

PROTECTING X-RAY MACHINE CABLE

Interlocked Stainless Flexible Metal Hose used to reinforce end of electric cable and prevent wiring failure.



BOILER—"HEADER HEATER" CONNECTIONS

Installation made quickly and easily through use of American Seamless Flexible Bronze Tubing connections.

WOULD YOU LIKE to make your product more convenient, safe or economical to install or operate?

Then look into the possibilities offered by American Flexible Metal Hose and Tubing.

Sturdy, leakproof connections of this material have improved literally thousands of types of products and equipment... from heavy machinery to small accessories. Illustrated are three examples . . . on each, flexible metal tubing is used to excellent advantage, yet for an entirely different purpose.

Find out where flexible connections in your product or equipment could better compensate for movement of parts, vibration and misalignment ... or where gases, liquids or steam could be conveyed more easily or safely.

Flexible metal assemblies are usually easy to order and install. If *your* needs are unusual, our Technical Department can probably help.

AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

Keep Faith With Your Fighters and Yourself!
Buy War Bonds for Keeps

ANACONDA

American Metal Hose

Masterfully Designed

You can install a Roots-Connersville Centrifugal Blower or Exhauster with perfect confidence that it has been engineered to provide a completely satisfactory unit. Every detail of construction, no matter how small, receives the painstaking care which contributes to smooth-running, high-efficiency performance. Centrifugal units built by Roots-Connersville are engineered to the job on which they will operate. The service conditions are carefully studied before the designing starts. Every detail—proportion of parts, blade contour, width and diameter of impeller, speed requirements, shaft dimensions, and types of material—is given the closest possible scrutiny by a staff of experts, backed by years of experience in handling air and gas.

It Takes More Than

APPEARANCE

to Do the Job!

A car with inferior "undercover" construction, but with a smooth streamlined body may have the same look of VALUE, when new, as the finest car built, but performance soon tells. Time is the test.

Installation above—Steam turbine driven 24" Centrifugal Exhauster handling foul gas in a New Jersey refinery, with a capacity of 19,000 CFM at 3 lbs. pressure; speed 4,750 RPM.

Ask us to quote on your specific requirements.

ROOTS-CONNERSVILLE BLOWER CORP.

One of the Dresser Industries

505 ILLINOIS AVENUE CONNERSVILLE, INDIANA

WRITE FOR BULLETIN 120-B-12

Roots Connersville SINCE 1854 — Centrifugal EXHAUSTERS and BLOWERS

CHEMICAL FLUORSPAR OUTPUT INCREASED IN SOUTHWEST

With the demand for acid-grade fluorspar expected to reach an all-time high of 135,000 tons this year in contrast to 128,000 tons in 1944 and 37,000 tons in 1940, a number of new and enlarged facilities for producing this vital chemical raw material has recently been put into operation in Arizona, New Mexico and Utah. The following table lists present fluorspar producing mills in these states and their approximate daily tonnage capacities:

International Minerals & Chemical Corp.,* Silver City, N. M.	300
Tintic Standard Mining Co.,* Lund, Utah	150
Edgar J. Marston,* Silver City, N. M.	90
General Chemical Co.,* Deming, N. M.	60
Indian Metals Co.,* Lordsburg, N. M.	50
Southwestern Minerals Co., Duncan, Ariz.	50
J. A. Campbell & Son, Wickenburg, N. M.	50
Essential Minerals, Ltd., Yuma, Ariz.	**
Manassa Mining & Milling Co.,* Milford, Utah	—

* Producer of acid-grade material. ** As a byproduct of lead-fluorspar ore.

NEW 100-OCTANE GASOLINE REFINERY FOR CURACAO

British interests have been given the cooperation of the Petroleum Administration for War in the construction of a $6,700,000 100-octane aviation gasoline refinery unit for the Royal Dutch Shell plant at Curacao, off the coast of Venezuela. Construction of the unit is part of the overall program to meet increased military demands for aviation gasoline. Orders for approximately $1,650,000 of materials to be fabricated in the United States already have been placed. The remainder of the materials will be obtained from Great Britain. The capacity of the new refinery cannot be announced because of military security.

CORRECTIONS

In our April 1945 issue article, "New Analysis Provides Formula to Solve Mixing Problems," typographical difficulties caused errors to appear in a number of the equations. Corrections, as supplied by the authors, are as follows:

The exponent of e in equations (15), (16), (18), (19), and in line 5, col. 3, p. 104 should have been: $-kS_p\,(1 - e^{-kt})$.

Delete expression "$[e^{-kS_p}$" from (18).

Logs in (8) and (9) are to the base e.

The best way to correct Equation (20) is to offer a new one:

$$[(P_3)'_R]\,[(P_3)''_R] = [1 - (e^F)^R]\,[1 - (e^G)^K] \quad (20)$$

where F, H, G and K have the following values:

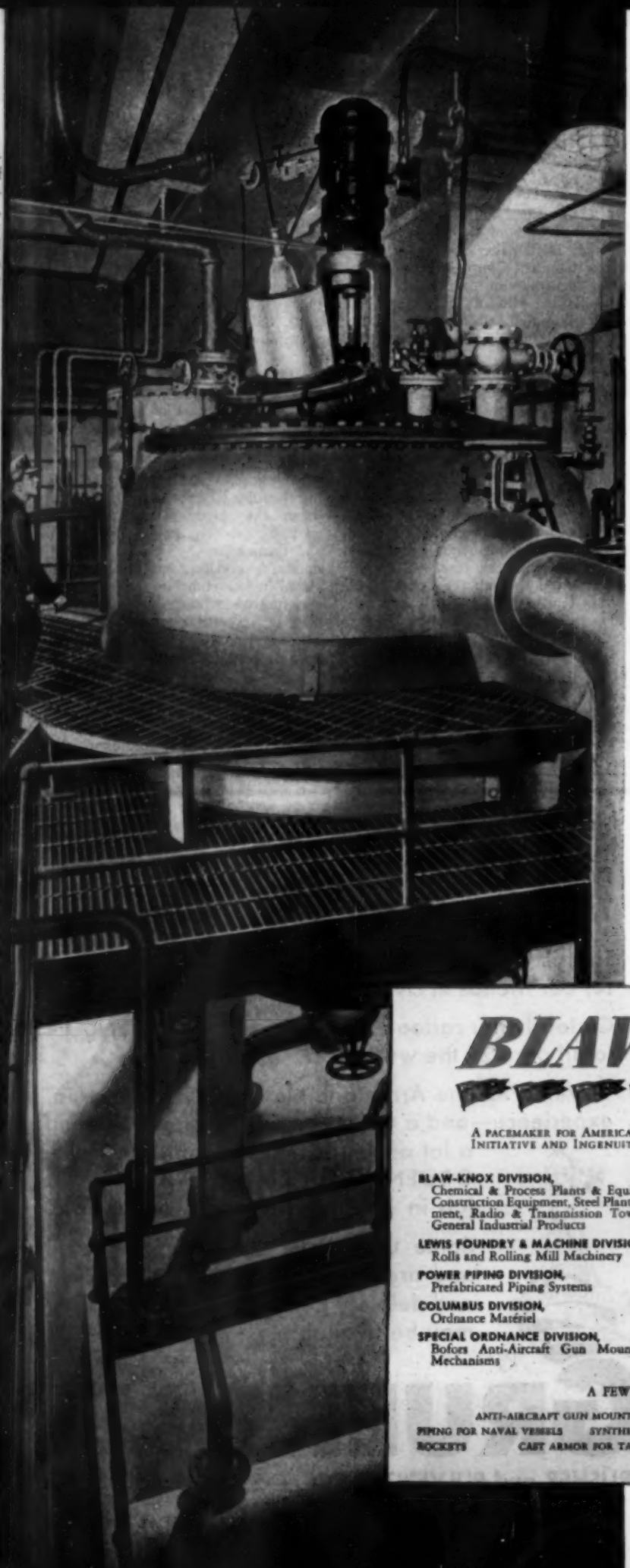
$F = -k'S'_p\,(1 - e^{-kt'})$

$G = -k''S''_p\,(1 - e^{-kt''})$

$H = v'/V$, and $K = v''/V$.

On page 106, col. 1, exponents of e in the two simultaneous equations are $-kS_p\,(1 - e^{-2k})$ and $-kS_p\,(1 - e^{-3k})$. Five lines further on, $-kS_p$ should be $= kS_p$. In col. 3 of the same page there are five corrections to be made: In lines 4, 5, 6 expressions in parentheses should be $(1 - e^{-kt})$, $(1 - e^{-kt})$, $(1 - e^{-kt})$; line 17, change $+ 5.22$ to $- 5.22$; change 1,109 to 1.109 in line 32.

In addition to the above changes, the authors have asked that a note be inserted that whenever, "at least one element" appears, it should be taken to mean, "some part of at least one element."



FIRST of its kind

SHOWN HERE is the first Dowtherm heated and cooled synthetic resin production kettle in this country. It exemplifies the chemical, engineering and fabricating "know-how" which Blaw-Knox offers to the chemical and process industries.

The leadership of Blaw-Knox has long been acknowledged in the design and production of rolls, rolling mill machinery and high temperature furnace equipment for the ferrous and non-ferrous industries. Also in numerous products emphasizing stability, efficiency and economy for railroads, electronics, public utilities, equipment for the construction industry and for industry in general, including prefabricated power piping and a host of other important products. A brief glance at the list of Blaw-Knox divisions will give you an idea of the engineering background, as well as the skills and facilities which Blaw-Knox can bring to an industrial problem within its scope.

BLAW-KNOX COMPANY

A PACEMAKER FOR AMERICAN INITIATIVE AND INGENUITY

2090 FARMERS BANK BLDG.
PITTSBURGH, PA.

BLAW-KNOX DIVISION,
Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

LEWIS FOUNDRY & MACHINE DIVISION,
Rolls and Rolling Mill Machinery

POWER PIPING DIVISION,
Prefabricated Piping Systems

COLUMBUS DIVISION,
Ordnance Matériel

SPECIAL ORDNANCE DIVISION,
Bofors Anti-Aircraft Gun Mounts and Mechanisms

PITTSBURGH ROLLS DIVISION,
Rolls for Steel and Non-Ferrous Rolling Mills

UNION STEEL CASTINGS DIVISION,
Steel and Alloy Castings

NATIONAL ALLOY STEEL DIVISION,
Heat and Corrosion-Resistant Alloy Castings

MARTINS FERRY DIVISION,
Bofors Anti-Aircraft Gun Mounts

BLAW-KNOX SPRINKLER DIVISION,
Automatic Sprinklers and Deluge Systems

A FEW VICTORY PRODUCTS

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NEWS FROM ABROAD

MOVEMENT FOR RELAXATION OF GOVERNMENT CONTROLS GAINS MOMENTUM IN GREAT BRITAIN

Special Correspondence

THE APPEARANCE of the British chemical markets has not altered materially in the past few months. Controlled supply and licensed demand are closely balanced, and the flow of deliveries on the one side and new inquiries and contracts on the other goes on steadily with imperceptible changes. Yet there is increasing evidence of a process of progressive de-control. Few instances, it is true, can as yet be quoted, and it would certainly be an exaggeration to say that the process has already gained momentum. But all evidence points unmistakably in one direction.

If china clay pits closed down to release labor for more urgent work are allowed to reopen, if export licenses are no longer required for nickel compounds, Prussian blues, or iron oxide pigments, if aluminum suppliers are permitted to sell the metal directly instead through the Light Metals Control, if phenol makers may send their product to whatever markets they like, the practical effect of control relaxation may be slight, at least as far as the market position in general is concerned, but the tendency is certainly promising, not least because those responsible for control in Britain have always shown the greatest reluctance to effect any changes which may have to be rescinded later on and would then upset the smooth flow of supplies.

There are weighty factors which deprive de-control in important fields of virtually all its practical importance. Exports, for instance, have hardly improved because of shipping difficulties. The 1944 exports of chemical manufactures—£28,090,000 against £27,520,000 in 1943—were higher only in value; their volume was only 80 percent of 1938. The shipping position still prevents chemical manufacturers from making full use of export licenses and opportunities; in some cases where licenses are granted only when merchandise is actually available for shipment, the shipping delay has involved would-be exporters in considerable storage and finance costs. Similarly some of the domestic producers authorized to reopen closed works complain of lack of labor and fuel which make government permission of resumed operations entirely fictitious. Nor does de-control of domestic sales amount to much since it is largely confined to articles which are in any case in ample supply. It is not, therefore, the present effect of relaxed control as much as the prospects held out for the future, and perhaps the near future, which have

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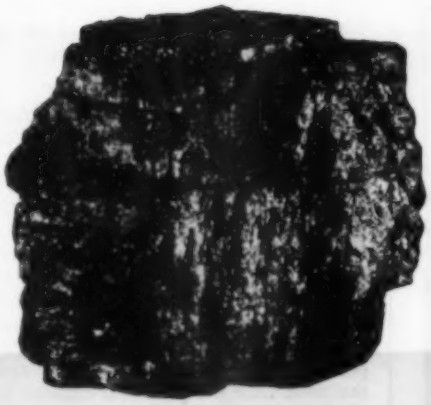

KOPPERS

. . . has a big place in the Coal Tar Chemical Field

1. Coal is the Great Chemical Reservoir—Two-thirds of the synthetic resins produced in the U. S. in 1942 (the last year for which published figures are available) were based on coal carbonization products. Koppers has been one of the nation's leaders in the carbonization of coal and in the utilization of the products of coal carbonization.

2. The Coke Oven Unlocks Chemicals in Coal—Coal burned under a boiler or in a furnace is consumed. Coal used in a modern coke oven is distilled or carbonized. From the gas and vapor come many chemicals essential to modern life and industry. Koppers is the largest American builder of coke ovens.

3. Koppers Plants Help Recover and Refine Chemicals—Koppers designs and builds many of the plants which recover and refine coal tar chemicals which go into synthetic rubber, plastics, varnishes, dyes, solvents, motor fuel, disinfectants, medicines, flavors, explosives, and other products. This photo shows a synthetic rubber chemical plant built and operated for the Federal Government by Koppers.

4. Koppers is One of the Principal Sources of Coal Tar Chemicals—Koppers serves the chemical industry by producing phenol, cresols, Xylenol, benzene, toluene, xylene, pyridine, picolines, lutidines, quinoline, other tar bases, naphthalene, tar acid oils, and other products.

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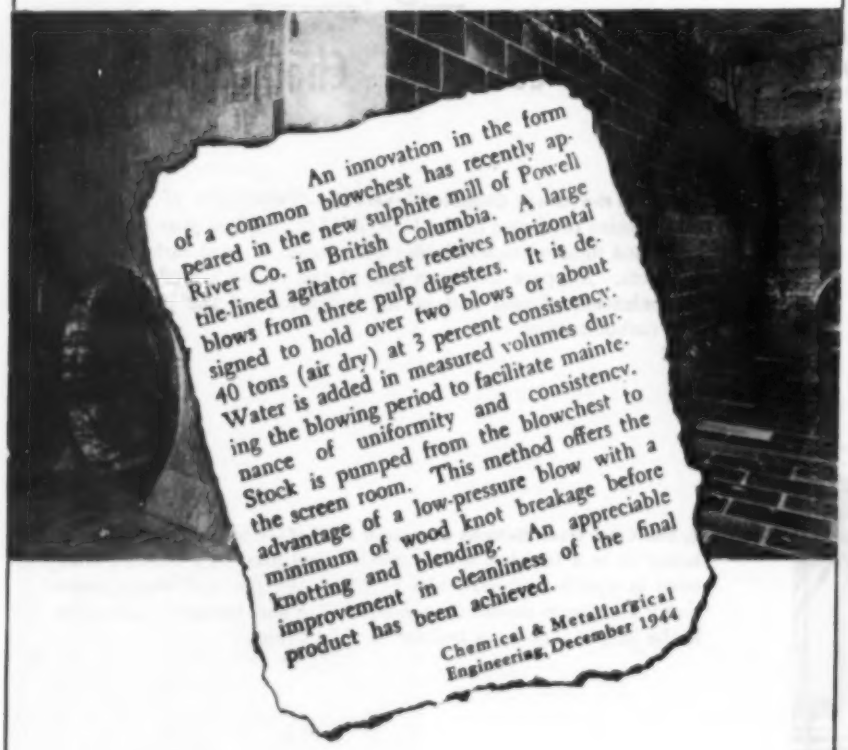
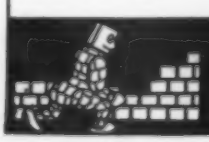

An innovation in the form of a common blowchest has recently appeared in the new sulphite mill of Powell River Co. in British Columbia. A large tile-lined agitator chest receives horizontal blows from three pulp digesters. It is designed to hold over two blows or about 40 tons (air dry) at 3 percent consistency. Water is added in measured volumes during the blowing period to facilitate maintenance of uniformity and consistency. Stock is pumped from the blowchest to the screen room. This method offers the advantage of a low-pressure blow with a minimum of wood knot breakage before knotting and blending. An appreciable improvement in cleanliness of the final product has been achieved.
Chemical & Metallurgical Engineering, December 1944

MAKING "innovations" work has been a large part of Stebbins job for sixty-one years. Whether in pulp or paper mills, chemical or metallurgical plants when linings and tanks are needed, Stebbins engineers, technicians and installation personnel, produce long-lasting, trouble-free installations.

Designing corrosion-resistant linings, both for acid and alkali conditions, is an engineering job. Stebbins experience in designing, installing and servicing linings and tile tanks is long in years and wide in the types of installations made. This experience extends not only throughout the North American continent, but to Central and South America and the Orient.

Stebbins handles the entire installation from start to finish, turning the completed job over to the customer ready for use.

Call in Stebbins whenever you have a lining or tile tank problem.



EMCO

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been noted as encouraging evidence of a marked change in government policy.

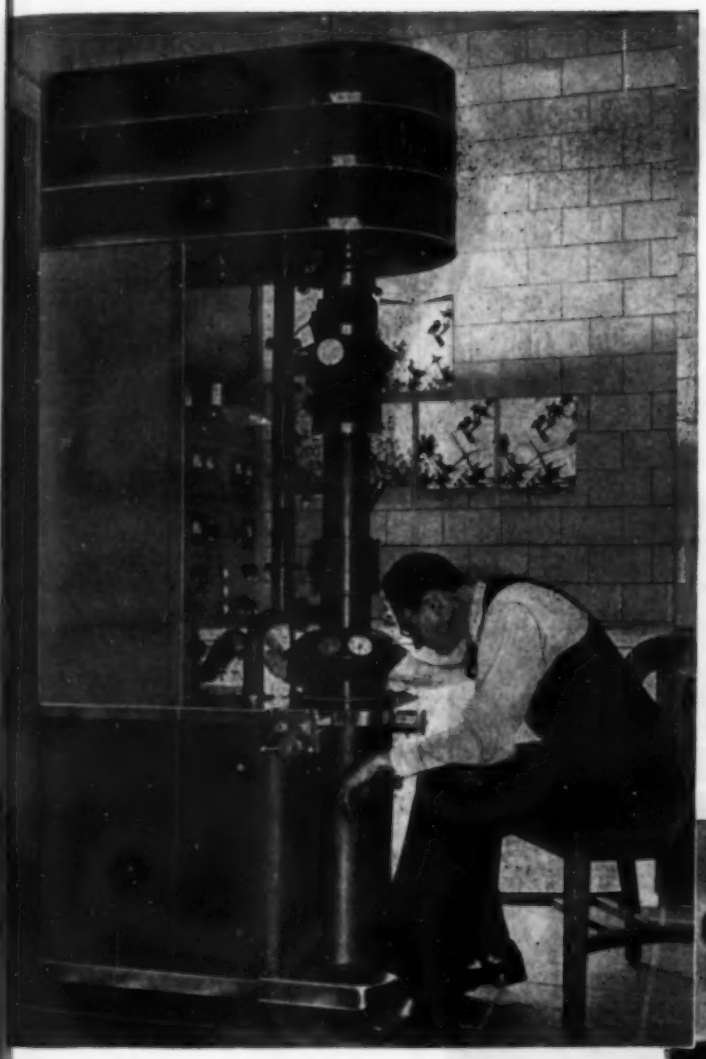
LIGHT METALS

Most significant perhaps are the changes in the field of light metals. Until recently two-thirds of all aluminum went into aircraft, and the rest was used to save weight in other armaments. Half the magnesium production found its way into aircraft too, and the other half was made into incendiary bombs. So revolutionary has been the change in the military situation during the past few months that the Control relinquished its marketing monopoly, giving producers the right of direct sales, and at the same time the price was reduced from £110 per long ton, the wartime quotation in force since November 1939, to £85 which compares with a prewar level of £94 and is only slightly higher than the U. S. price of 15c. per lb. This indeed is significant, for it must certainly have been obvious to the authorities that the export prospects of British fabricators would have been nil had the future price been pegged at a higher level. Even in the home market a higher price would have put domestic manufacturers at a serious disadvantage as compared with importers, while with a home market price down to the world market level the efficiency gained by recent investments is thought sufficient for local manufacturers to withstand outside competition.

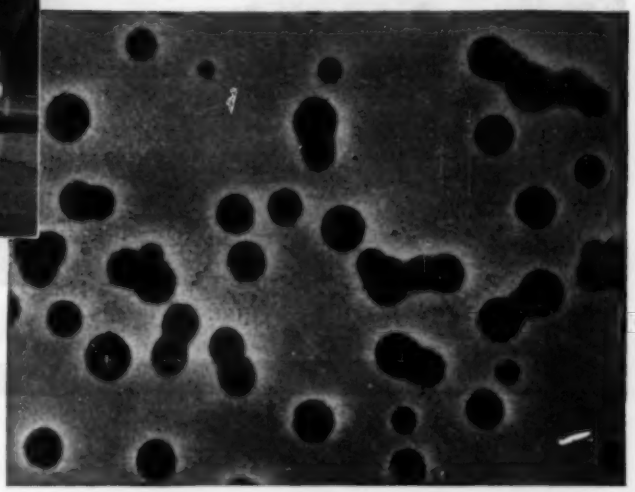
The high level of raw material prices and of the cost of fuel and labor is viewed with considerable concern in industrial quarters which are much worse off than before the war in the matter of taxation and plant condition. If, as is feared, repair and renovation work put off in wartime has to be made good at greatly elevated cost after the war, the necessary higher depreciation allowance plus increased current costs may seriously affect the British chemical industry's competitive power. A cut in raw material costs is therefore essential, but a gradual sliding down of prices would hardly fit the industry's needs. It would retard the re-stocking process, introduce an unknown factor into industrial calculations, and thus have an unsettling and thoroughly undesirable effect.

That the government agency decided on an immediate cut of the aluminum price by as much as one-quarter is regarded as proof that the authorities realize these facts and do not shrink from drastic action if necessary. Moreover, other prices will clearly have to follow suit; copper and other metals are most directly concerned, but from here the downward trend is likely to spread, especially if it is supported by government policy. For as long as official control of production and prices lasts, the authorities have it in their hands to effect whatever price changes they desire, possibly by reliance on such means as subsidies, tax concessions, credit grants, etc., to compensate reluctant producers.

Drastic price reductions are not equivalent to de-control of prices but rather a prelude and indeed prerequisite to de-control, since wartime prices have moved away from their natural line in a free market. This tendency was not checked as long as government agencies were the principal sellers and buyers and even exports consisted largely of reverse lend-lease



Goodyear Tire and Rubber Company Tells How the RCA Electron Microscope Helps Manufacturers



Micrograph made with RCA Electron Microscope showing Synthetic Rubber Latex Particles x 25,000

THE RCA Electron Microscope showed Goodyear scientists that particles of natural rubber latex range in size from as little as 4 millionths of an inch to as much as 160 millionths; and that the size of synthetic latex particles ranges only from 0.8 to 7.2 millionths of an inch. This information indicated to Goodyear research men answers to several questions of great importance to rubber manufacturers, namely:

1. Why has synthetic latex so much greater mechanical stability?
2. Why is it impossible to concentrate synthetic latex by centrifuging, as is done with natural latex?
3. Why has synthetic latex greater viscosity than that of natural latex having the same content of solids?
4. Why does synthetic latex impregnate fabrics more readily than does natural latex?

Here is an excellent example of the practical value of the RCA Electron Microscope—how it helps manufacturers—how it can be used, not only in research but in checking production for particle size, structure, distribution, etc., for better control of product quality.

RCA Electron-Microscope engineers will gladly advise any manufacturer of the probability that an instrument of this type will prove profitable in his work. Please address inquiries to Electron Microscope Section, Radio Corporation of America, Department 116S, Camden, New Jersey.

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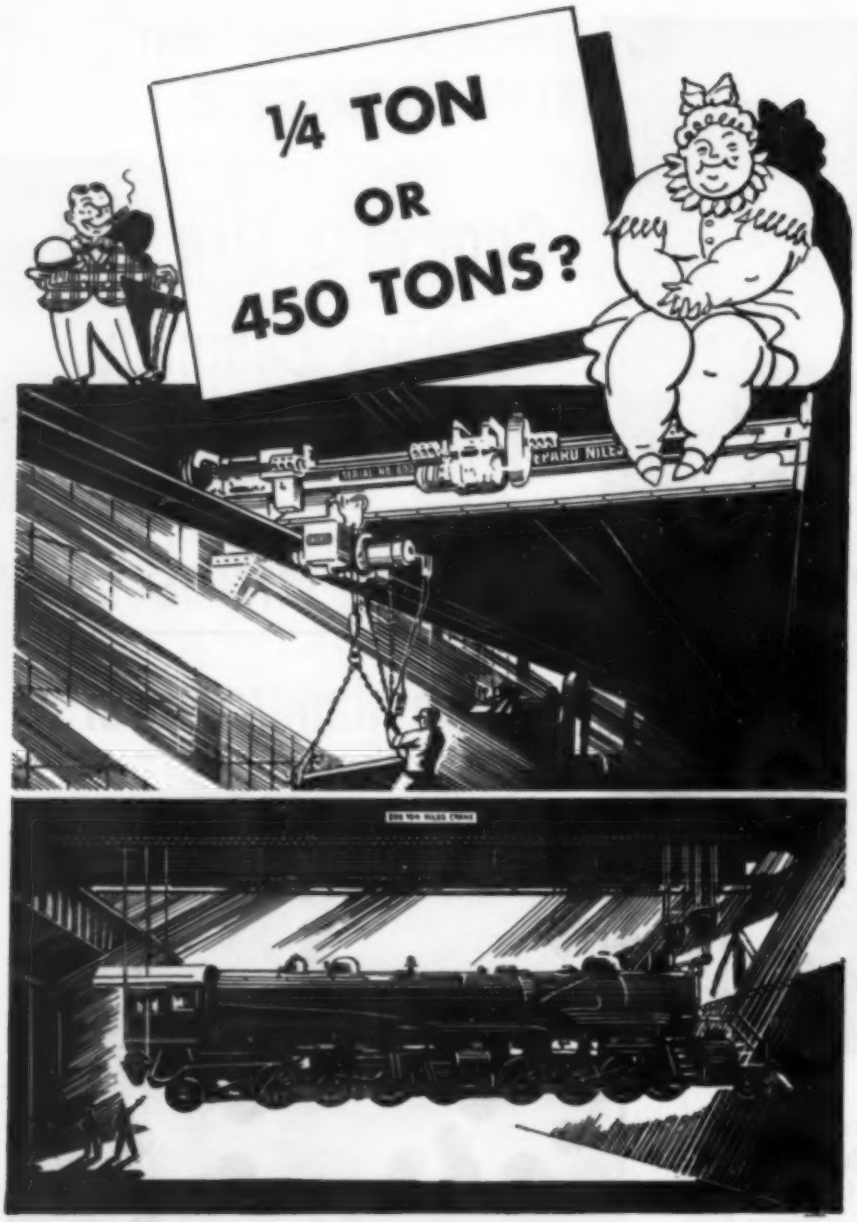

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shipments and similar consignments Empire destinations. British chemi manufacturers are certainly on the side those who favor marked price cuts for raw materials, and well-informed observe are not adverse to such reductions bei effected by official controls.

MONOPOLIES

It is indeed doubtful whether the g ernment will ever completely abandon control rights since wartime amalgamati and concentrations have accentuated t trend towards wider establishment of p duction monopolies notable even earlier British chemical trade. A recent offic investigation revealed that quite a numb of important products are now made clusively or predominantly by one or t firms. The list includes aluminum oxi anhydrous ammonia, ammonium chlori borax, calcium carbide, carbon bisulphi cellulose acetate, liquefied chlorine, ace lene, oxygen, magnesium chloride, meth alcohol, phosphorus, cream of tartar, oxide, zinc sulphate, sodium carbon and also dyestuff intermediates, indigo a few important pharmaceuticals phenacetin. The list is based on a cen taken in 1935 since when conditions h changed, but the problem itself has altered. The British public is more crit now of industrial monopolies than it some years ago and may favor continuat of control in some supervisory form.

CANADIAN REQUIREMENTS FOR INSECTICIDES

UNOFFICIAL estimates state that ann requirements for insecticides in Can amount to about 2,000 tons of lead senate, 1,800 tons of calcium arsen 600 tons of paris green, and 75 tons nicotine sulphate. Imports of pyreth and rotenone approximate 150 tons a y

CALCIUM ARSENATE PLANT BUILT IN MEXICO

PRODUCTION of calcium arsenate is a to commence at a new plant constru in Juarez, Mexico. The new productio planned to take care of agricultural requ ments in that area, particularly to sup growers of cotton. The schedule calls an output of one metric ton of calc arsenate daily and about 100 kg. of w arsenic.

ECUADOR OFFERS LIMITED MARKET FOR PLASTICS

ONLY a small potential market plastic products exists in Ecuador, chief demand being for tableware kitchen utensils. These items are pensive and it is believed that a l priced line would be well received. Th is no production in Ecuador which plastics raw materials except an ann consumption of approximately 1,200 used in paints and varnishes.

SPAIN INCREASES CONSUMING REQUIREMENTS FOR SULPHUR

SPAIN produced approximately 32 tons of sulphur in 1944 and all of thi marked for home consumption. An

Chemicals....

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Time is not just something measured on the face of a clock; it means far greater things—lives saved, battles won, honor defended. The Stauffer Chemical Company, in supplying war industries and the armed forces with an incredible number of products, has done so at top speed. Yet, in manufacturing and distributing these products in a hurry, Stauffer has not sacrificed an iota of the quality of its chemicals. Into ships, planes, bombs, rubber, uniforms and a host of other military necessities, have gone Stauffer Chemicals. Stauffer has delivered the goods p. d. q.—but each product has been of the same traditionally high quality that has won for Stauffer its enviable reputation over the past sixty years.

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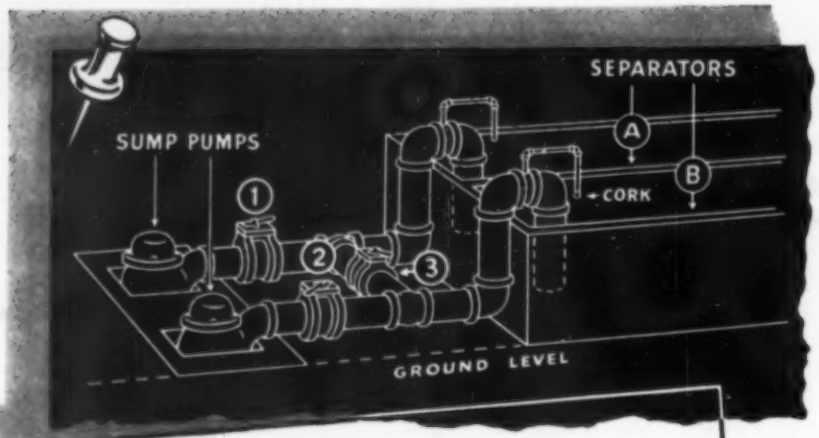

How to Control Sump Pump Discharge

The plant sewer lines drain into the sump where the waste is pumped into the concrete separators through R-S Valves Nos. 1 and 2. Valve 3 in the connecting line provides a means of cleaning either A or B separators, as the ¾-inch syphon breakers can be plugged with corks and the fluid syphoned from the separators to facilitate cleaning operations. The three 16-inch, 15-pound valves have 25-pound American Standard flanged drilling and are hand lever operated.

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No. 625. 150-pound three-way valve with air cylinder positioner control and adjustable linkage. Ideal for mixing and interchange service. Precision engineered metallurgically and mechanically.

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R-S Streamlined BUTTERFLY VALVES

crease in production will be necessary th year as consuming requirements are mou ing with a good part of the increase sa to be due to the growing outputs of sy thetic fibers.

SICILY RENEWS PRODUCTION OF SUPERPHOSPHATE

ALTHOUGH most urgent needs were su plied by the Allies, a shortage of fertiliz continued in Sicily throughout last ye Three superphosphate plants, part of t Montecatini group, have resumed op ations. The largest of these has a month capacity of 2,500 metric tons a month. was hoped that shipping conditions wou permit the importation of sufficient pho phate rock from North Africa to enab these plants to produce most of the supe phosphate to meet local requirements. 1944 imports of phosphate rock amounte to 15,000 metric tons.

SWEDEN SEEKS TO UNCOVER NEW SALT DEPOSITS

THE rationing of salt in Sweden h stimulated interest in prospects of obta ing salt from the wells at Hollviken. Th 8 percent brine solution that has be obtained at the 1,200 meter level requir large quantities of fuel for the evaporati process. In the hope of finding a strong solution at a greater depth, application h been made for an appropriation to drill a depth of 2,000 meters. The increase consumption of salt from about 170,0 metric tons before the war to more tha 200,000 tons since then is attributed t expansion in the domestic chemical indu try which consumes approximately 50 pe cent the total salt requirements.

VANILLIN PRODUCTION STARTS IN CANADA

ACCORDING to unofficial reports vanill is now being produced in Canada b Howard Smith Chemicals, Ltd., which a subsidiary of Howard Smith Paper Mill Ltd. Current production is said to b sufficient for domestic requirements wit a surplus for export which is going to th United Kingdom.

CUBA INCREASES OUTPUT OF ALCOHOL

THE industrial alcohol industry in Cub is operated in connection with the sug industry and in some cases as an adjunc to sugar mills. It showed substanti growth last year with 57 distilleries i operation at the close of the year wit 27 active in 1943 and 23 in 1942. Pro duction of industrial alcohol amounted t 51,000,000 gal. in 1944 compared wit 27,000,000 gal. in 1942 and 8,750,00 gal. in 1939. A large part of production was exported last year.

FRENCH GLASS INDUSTRY

PRODUCTION in the window and plat glass industry of France was expected b the Ministry of National Economy to b at the rate of 1,560,000 square meters o window glass per month by last Februar

CORROSION FORUM

EDMOND C. FETTER, Assistant Editor

MODERN MATERIALS • MODERN METALS

NEWS BRIEFS

PROPER packaging of spare parts of military plane propellers, instruments, and accessories for delivery in immediately usable condition anywhere in the world is being studied by the Aircraft Accessories and Equipment Subdivision of the Society of Automotive Engineers. With the idea that standardization of this procedure may ultimately be effected, the Subdivision has undertaken a comprehensive program of coordinating parts lists, specifications, and recommended practices for preservation and packaging. The program is being prosecuted by 16 subcommittees under the guidance of a new steering and coordinating group, Committee A-13, comprised of subcommittee chairmen, with Paul J. Konella, Pratt & Whitney Aircraft Div., United Aircraft Corp., East Hartford, Conn., as chairman. Each subcommittee has been assigned a specific field (e.g., bearings, pumps and valves, carburetors, instruments, etc.), and each will prepare parts lists and make recommendations for packaging against climatic extremes, rough handling, unprotected storage, corrosion, and fungi.

A NEW, tri-metallic plating process has been developed by the Westinghouse Co. Copper, tin, and zinc are simultaneously deposited on delicate, intricately shaped parts of such instruments as chronometers and speedometers to provide a protective coating which is bright and shiny, tough, non-magnetic, only 0.002 in. thick, and corrosion resistant enough to show no signs of attack after the standard 200-hr. continuous salt spray test.

CORROSION REPORTER

AMONG other experience data reported this month is the unusual case of a rubber-covered agitator which successfully withstands exposure to *boiling* hydrochloric acid. The installation is described as follows by the corrosion engineer in a large heavy-chemicals plant: "One of our products is a zinc chloride solution which we manufacture from a zinc sludge (metallic zinc and ZnO) by dissolving the sludge with concentrated **hydrochloric acid** (37.5 percent), filtering and evaporating the resulting filtrate to the desired concentration of zinc chloride. The dissolving tank where the sludge is treated with hydrochloric acid is brick-lined steel. An agitator in this tank was a perpetual source of trouble. We had been making the agitator out of wood and usually got no more than a few months service from it. We thought of using a steel assembly coated with hard rubber but were reluctant to do so because the heat of reaction kept the temperature close to 100 deg. C. No rubber manufacturer would guarantee such an installation because of the high temperature, although rubber is well known for its resistance to hydrochloric acid at low temperatures. However, we obtained a number of samples of various hard rubber compounds and after considerable testing we found one which seemed to justify a trial installation. The trial agitator, constructed of steel coated with hard rubber, has now been in service for 1.5 years and shows no signs of deterioration. We believe it is quite remarkable to find a rubber compound holding up so well under exposure to hydrochloric acid at 100 deg. C. The rubber used is one of the Manhattan Flexlastic synthetic rubber compounds.

"The saturated zinc chloride solution is stored prior to shipping in lead- or rubber-lined tanks and is shipped in rubber-lined tank cars or in steel drums. The choice of storage container and shipping container depends upon our customer's lead or iron tolerances.

"Fumes given off from the dissolving tank were formerly carried outside in a wooden flue which usually fell apart in less than four months. The wooden flues have now been replaced with Transite type S (Johns-Manville) and these still look good after 1.5 years.

"We buy **nitric acid** as 38.5-deg.-Bé acid and store it in a welded tank made of 16-percent-Cr stainless steel. We pump this acid through piping made of stainless type 347, using a pump made of 18-8 stainless. A siphon used to fill glass bottles is made of aluminum."

THE CHIEF chemist with a concern engaged in the manufacture of sodium silicates has a word of warning for those who would subject stressed steel to hot caustic soda. In his words: "The manufacture of sodium silicate requires the use of only one material which might be considered corrosive, namely, sodium hydroxide. This we buy as a 50-percent solution in tank car lots. It is pumped with cast iron pumps through steel pipes into a steel storage tank. There has been no sign of caustic embrittlement in any of this equipment. From storage, the caustic solution is delivered to a steel tank containing a steam coil where it is heated to the boiling point in preparation for the production of sodium silicate. The hot caustic does not damage the steel tank, but did cause severe pitting on the outside, or caustic side, of the welded steel coil. However, the pitting was confined to those portions of the coil where a sharp bend had severely stressed the steel during fabrication. The attack was of equal severity at both the hot and cold ends, and there was apparently no correlation between corrosion and the presence or absence of condensate. To solve the problem, we installed a steam coil made of 18-8 stainless steel. It was designed the same as former steel coils, with the same sharp bends, but there has been no pitting or corrosion of any kind throughout its length."

LITERATURE REVIEW

"CORROSION; Effects of Welding," *Welding Journal*, Jan. 1945, p. 45:—One page is reprinted from the International Nickel Co.'s 54-page booklet, "Corrosion." Welding of corrosion-resistant alloys and alloy-clad steels is discussed in general terms, and test data are given to show the effect of welding on the resistance of Monel, nickel and Inconel.

"AMINES Check Corrosion in Condensate Return Line," *Power*, March 1945, pp. 71-73; abstracted from U. S. Bureau of Mines Report of Investigations 3754:—A volatile alkaline amine was added intermittently to the boiler feed water of a steam heating system, and the condensate from various points in the system was analyzed at regular intervals to determine its pH and its amine content. By plotting these on the same graph against time, it is shown that pH and amine content rise and fall together. Presumably the transformation from the acidic to the neutral or alkaline condition makes the condensate less corrosive. The graphs also show that intermittent, as opposed to continuous, feeding is unsatisfactory.

A. RASCH and R. Weihrich (of Poldihütte, Kladno, Germany), "Acid-resisting steels for chemical plants," *Chemische Fabrik*, 12, 1941, pp. 231; reprinted in *Chemical Age*, Dec. 2, 1944, pp. 521-524, and Jan. 6, 1945, pp. 15-16:—Practical experience during the 25-30 years that high Cr and Cr-Ni steels have been used in the chemical industries shows that for many purposes plain Cr, Cr-Mo, Cr-Mn, or Cr-Mn-Ni steels may be employed instead of the customary 18-8 stainless steels. For example, the thick-walled, high-pressure vessels used for ammonia synthesis were, according to Claudia, constructed from high Ni alloys containing upwards of 56 percent Ni. However, the much lower alloyed 12-12 Cr-Ni steels, with additions of W and V, have for many years proved to be more satisfactory. Calenders used in the paper industry, originally made from bronze and later from 18-8 Cr-Ni steels, have for some time given equally good results if produced from Cr-Mn-Ni (18-14-1.5 or 18-9-1.5) steels or from straight 15-Cr steel. In place of 18-8 stainless for equipment in the milk industry 17-Cr steel or the above Cr-Mn-Ni steels are satisfactory.

The most important corrosion resistant steels used today in the chemical industries may be divided into four classes according

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12 EAST 46th STREET, NEW YORK 17, N. Y.

to their composition (representative) microstructure and properties: (1) Cr (1[7] percent) steels, ferritic-pearlitic structure magnetic; (2) Cr-Ni (18-8) steels, austenitic, nonmagnetic; (3) Cr-Mn-Ni (18-14-1.5) steels, austenitic, nonmagnetic (4) Cr-Mn-Ni (18-9-1.5) steels, ferritic austenitic, weakly magnetic.

Straight Cr steels (group 1) are almost as resistant as 18-8 and show good resistance to nitric acid, nitrous vapors, fats, oils, alkali solutions, and many salt solutions (copper sulphate, photographic developers, etc.). They are not, however, sufficiently resistant to sulphuric and hydrochloric acids and chloride solutions, especially heavy metal chlorides. A disadvantage of the straight Cr steels is that heating above 95[0] deg. C. causes grain growth which in turn causes increasing brittleness. Welding is advisable therefore, only if the mechanical requirements in use are very moderate. These steels are particularly suitable for solid members such as shafts, spindles, valves and valve seats.

The Cr-Ni steels (group 2) have found their most general application in high-pressure equipment. All the 18-8 steels may be welded and that, coupled with their high inherent resistance to corrosion, explains their preeminence among stainless steels. The danger of intercrystalline corrosion in the weld zone may be circumvented easily in the case of small fabrications by heating to about 1,100 deg. C. and quenching, and in the case of large structures by the incorporation of carbide-forming elements (Ti, Ta, or Nb) in the alloy. In either case the addition of Mo is beneficial, although several years' working experience has shown that even for such severe requirements as pipes and valves in sulphite cellulose plants the Cr-Ni-Mo steels (with carbide agents) need only contain 1.8 instead of 2½ percent Mo. In particular, in the sulphite cellulose industry, in rayon production, for acid dyeing baths, and in wool bleaching plants the 18-8 Mo steels are used in preference to straight 18-8. In welding steels containing carbide formers, great care must be observed in the welding operation or the efficacy of the stabilizer in preventing weld decay is lost. For example, Ti (unlike Nb) is very easily burned out during welding and grain corrosion may result just as though there were no Ti in the steel.

All the Cr-Mn-Ni steels (group 3) possess good toughness at very low temperatures (down to —250 deg. C.) and are, for this reason, superior for certain applications to other steels, including 18-8. Its corrosion resistance is good but not as good as 18-8. It is, however, tougher than the straight Cr steels and possesses many technical advantages (deep-drawing properties and good weldability) and is widely used in place of the 17-Cr steel in the food industry. The steel can be cold-drawn to make corrosion resistant springs and it welds well, though its stability to intercrystalline corrosion is not perfect and the addition of carbide-forming elements is fruitless.

Application for the low-Mn Cr-Mn-Ni steels (group 4) is limited. They have greater strength than group-2 steels and are sometimes used for similar purposes where greater strength is required.

FROM THE LOG OF EXPERIENCE

DAN GUTLEBEN, Engineer

SAN FRANCISCO was a busy place in 1907. The town had been severely dealt with by earthquake and fire. There was a grand scramble to set it up again and everybody was eager to help for a consideration. Brother Phil and the chronicler joined the crowd and laid some bets on the gamble. Just as the means of subsistence was about to vanish, we landed a job! The first task was to coax the material men into delivering materials and to convince them that they would get their money as payment came in from the owner. Business was good and material dealers hesistated about taking on new and unproven accounts. Our list of 200,000 ft. of lumber excited no interest. One dealer after another turned it down with a twitch of the nose. At last Wilson Bros. Lumber Co. was reached and Manager Johnson said, "Sure, I'll take a chance." Likewise, after long effort, other dealers were found who expressed a willingness to take the risk and thus the first job was completed with profit. Years later, when our custom became attractive, Johnson was still furnishing our lumber in spite of importuning competitors!

THE FIRST concrete foreman that we employed in San Francisco asked if he was expected to save a little money for the House! He was instructed to adhere to the specifications. He touched his hat and replied, "Aye, sir, I can do it either way."

We found that some general contractors prepared their tenders by assembling quotations from specialty contractors, and, after the award of the job, they continued to shop around till the lowest price was reached. If some poor devil made a mistake, they shed crocodile tears. There was jockeying between the owners and the builders as in the case of the little street urchin who had a dollar. He went from shop to shop alternately exchanging his dollar for 20 nickels and then back again to a dollar. He explained that sometime "somebody is gonna make a mistake but it ain't gonna be me."

The fringes of the industry are like the slums of the city. A well-known waterfront contractor, notorious for his sharp practices, had the habit after winning the contract of beating down the sub-bidders whose bids he had used. The estimator of Judson Rolling Mill once quoted to this contractor on a quantity of structural steel, and afterwards discovered that he had omitted a large item. He betook himself to the contractor's office. There he was met by the bantering ejaculation, "I've got you beat a mile." This was, of course, untrue, but it gave the estimator an opportunity to withdraw his bid and transfer the loss of his error to the chiseler.

Specifications and plans lacked perspicuity. If it irked the architect to be specific, he charged the contractor with responsibility for "items not particularly shown or mentioned," but otherwise necessary to the complete job. A vast amount of ignorance and leeway was concealed under the modifyer, "proper," to qualify any material or workmanship. During the execution of the contract for a reinforced concrete addition to Mitchell's lithographing plant, the architect brought revised plans to the job including items not shown in the original drawings which were on file at the Hall of Records. We proceeded with the installation in the expectation of receiving recompense. Mitchell's superintendent advised us that his boss had instructed him to watch the construction vigilantly and make note of any departures from the specifications. At the completion of the job, when corrections could not be made except under the penalties of time extensions, the information was to be used for extortion from the last payment.

We worked on Sundays at premium rates of pay, and thereby finished so as to entitle us to a specified bonus for five days. On those Sundays, Mitchell used to parade past the job after church services, dressed in facial piety, a Prince Albert, and a silk hat and having his notebook in his hand. In spite of his vigilance, he could find no irregularities. But he refused to pay for the extra items or the bonus and his architectural umpire agreed with him.

BROTHER PHIL'S FAMILY laid claim to great friendship with the family Magerstaedt. This family included a bachelor maid who was endowed with an ample annuity; otherwise, she busied herself with her knitting. She was the owner of some of the high land overlooking the Russian River north of San Francisco, and she selected a particularly beautiful elevation for a summer cottage. Phil planned a rambling arrangement of special attractiveness and was told to proceed with the work.

When the job concerns the construction for a bachelor maiden of a thing so intimate as the home in which she will live or the gown in which she parades, she can be expected to spend a good deal of time in personal supervision. Phil's social obligations created a delicate situation. To avoid eventual embarrassment, Phil provided plans of unusual clarity, made special effort to have the drawings thoroughly understood, and then submitted a lump-sum price. She lived through the construction and was continually ordering changes. Some door or window was not what she had visualized either as to size or location. The beautiful pine floor was laid and sanded before she noticed that it was not maple. The foreman told her of the approximate costs of the changes that she requested from time to time, and when the cottage was finished, there was an imposing list of extras which were added at field cost only.

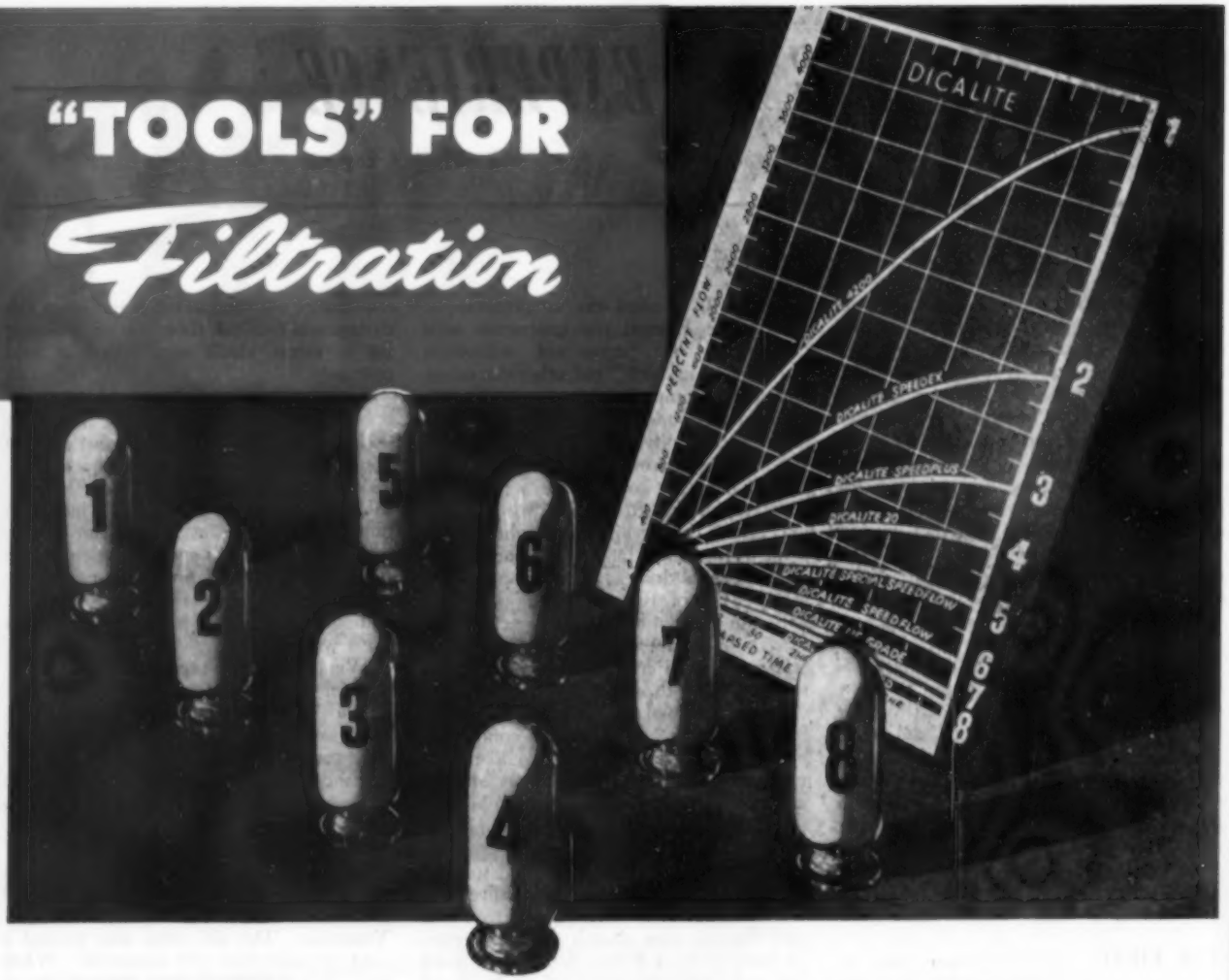
She came to the office with blood in her eyes! She started with Item 1 and forthwith we scratched it off the list with a flourish; and thus with the 2nd, and 3rd, and 4th—they were little items anyway. We did not even give her a chance to finish the sentence as it does not pay to prolong a customer's agony! Presently, she began to falter, and finally wound up by writing a check for the entire bill and adding an invitation to bring the family for a weekend.

We had a little experience with building for women. One Irish widow for whom we were building an apartment house complained that the window weights were rusty. Another was not superstitious but she did not want the house started on Friday. Another requested a "6" in her number plate as this was the fortune-bringing digit.

Also it is unlucky to build a clubhouse for a group of wealthy old men. Phil built one of these in the mountains above Yosemite. The old men also needed a road to make their pile accessible. When the job was finished, they did not like to be annoyed with little bills, and so they relieved themselves by going through the process of bankruptcy.

AFTER THE GREAT FIRE, Actor Caldwell forsook his profession and joined company with a practical builder possessing skill but a small cruising radius. Caldwell's delightful personality attracted custom and the business expanded and prospered. As the cycle of general prosperity declined, the great hazard which beset the contractor caught up with the actor, but did not dim his resourcefulness. He had just completed the Hall of Justice on Kearny Street and had somehow collected his final payment without remitting his own obligations on the job. The legal 35-day lien period ran its course. Then a rumor, said to have been started by himself, got around that Caldwell was broke! Creditor Drusick, greatly concerned, 'phoned about his $20,000 bill for cornice work. Caldwell, affecting great emotion, hollered into the receiver, "Drusick, I'll give you $15,000 for a receipt in full. Will you take it or not?" Drusick took it. Then the psycho-analytical Caldwell got into quick action, and before sunset, he had discounted all his bills, and turned a low bid into a profitable job. Each creditor in turn, thinking that he alone was thus favored, was stampeded into settlement. This episode has a certain apocryphal quality, but nevertheless, it contains a suggestion!

"TOOLS" FOR *Filtration*



. . . that improve operating flexibility, help maintain quality, increase production and reduce filtration costs.

● They are not magic "cure-alls" but Dicalite filteraids can help a great deal in improving today's operating conditions. By choosing a grade according to your needs you can make sure of: (1) thorough and positive removal of suspended solids, securing desired clarity that facilitates further processing; (2) higher filtration capacity that means increased output at lower unit costs. Dicalite filteraids give high flowrates for faster filtration, liquors with the brilliant clarity that comes from the removal of finest impurities such as bacteria, affords longer cycles and greater throughput. A Dicalite Filtration Engineer will gladly consult with you on any present or future problems.

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NAMES IN THE NEWS

William R. Veazey, vice president of the Dow Chemical Co., has been elected president of The Electrochemical Society for the 1945-46 term.

James H. McGraw, Jr., president of the McGraw-Hill Publishing Co., was awarded an honorary degree of doctor of engineering by Rensselaer Polytechnic Institute on April 22.

William M. Shine and **Philip G. Stevens** have joined the Development Division of General Aniline and Film Corp. Mr. Shine was formerly with the Plastics Department of General Electric Co. and Dr. Stevens was an instructor at Yale University.

Theodore A. Havens, Jr., has joined the Wickwire Spencer Metallurgical Corp. as tungsten engineer.

Charles A. Thomas, director of Monsanto Chemical Co.'s Central Research Laboratories at Dayton, Ohio, has been elected a vice president of the company. Effective September 1 he will become a member of the company's Executive Committee. Dr. Thomas will move to St. Louis and **Carroll A. Hochwalt** succeeds him at Dayton.

J. F. T. Berliner has resigned from his position with the Ammonia Department of E. I. du Pont de Nemours & Co. to join Engineering Associates, a consulting and engineering design group with headquarters in St. Charles, Ill.

E. C. Pitzer has joined Foote Mineral Co. as head of the inorganic research group.

Elmer Shaw Pettyjohn has been named director of the Institute of Gas Technology at Illinois Institute of Technology to succeed **John I. Yellott**. Until the time when Commander Pettyjohn's naval assignment is terminated, associate director **L. J. Willien** will be in charge. Mr. Yellott has left the Gas Institute to become director of research with the Locomotive Development Committee of Baltimore, Md.

L. A. Mekler, combustion engineer and member of the Engineering and Development Department of Universal Oil Products Co., has assumed a new position as engineering consultant to the Institute of Gas Technology and the Armour Research Foundation of Illinois Institute of Technology.

Garland H. B. Davis, director of the research division of Standard Oil Development Co.'s Esso laboratories, has been appointed to the marketing specialists group of Standard Oil Co. (N. J.) where he will be in charge of sales research and engineering. **E. Duer Reeves** succeeds Mr. Davis as research division director and **F. L. Miller** becomes associate director.

C. L. Knowles, technical director of General American Process Equipment, and **G. T. Reich**, technical director of the Pennsylvania Sugar Co., made a two-week trip to Havana last month. Sponsored by the Cuban Inter-American Development Commission, both delivered lectures on suggested ways and means of recovering by-products from the fermentation of molasses to alcohol. Both Dr. Knowles and Dr Reich were made honorary members of the Cuban Engineering Society.

Benjamin Sweedler, a chemical engineering graduate of Yale University, and a law graduate of Georgetown University, has resigned from his position with the Patent Division of Allied Chemical & Dye Corp. Mr. Sweedler has opened an office in New York for the practice of patent, trade mark and copyright law.

H. L. Wolcott, manager of the Morgantown, W. Va., Ordnance Works which DuPont operates for the government, has been appointed manager of DuPont's new Sabine River Works being built near Orange, Tex.

J. A. Holladay, recently elected vice president of U. S. Vanadium Corp., has assumed charge of the newly formed Metal Chemicals Division, with headquarters in New York.

Curtis C. McDonnell has retired as chief of the insecticide division of the livestock and meats branch of the Office of Marketing Services. Dr. McDonnell has served in the Agriculture Department since 1907. **W. G. Reed** has been appointed to succeed him. Dr. Reed has been with the Department since 1929.

J. D. Gordon, a chemical engineering graduate of Georgia Tech, has been appointed eastern representative of the Gas Processes Division of the Girdler Corp. His offices are in New York City.

A. D. Camp, who has been manager of the Technical Data Division and advertising manager for the Dorr Co., has been assigned to the company's Foreign Sales Division.

David Gordon, recently chief engineer for the Interchemical Corp, has joined the staff of Foster D. Snell, Inc., as director of engineering.

John L. Young has been elected to the newly created position of vice president in charge of engineering of the National Tube Co.

Harold W. Rehfeld has been named factory manager of the new government tire plant at Tuscaloosa, Ala., which is being built and will be operated by the B. F. Goodrich Co.

Alfred J. Stamm, a member of the Forest Products Laboratory staff for nearly 20 years, has been appointed chief of the Laboratory's Division of Derived Products.

Robert J. Taylor has accepted an appointment as research associate in Southern Research Institute where he will specialize in the chemistry of cellulose and related subjects.

W. F. Zimmerli has resigned as vice president of General Aniline & Film Corp. to engage in private practice as a consultant with offices in New York.

J. D. Grothe has been appointed by the Dorr Co. to head its newly created technical division of the sales department. The new division coordinates contract engineering orders and serves in a technical advisory capacity to the company's field staff divisions.

Arthur W. Lissauer, general manager of the General American Transportation Corp.'s Process Equipment Division, and president of Louisville Drying Machinery Co., has been elected a vice president of the corporation.

Charles J. Brand, who recently resigned from his position as chief executive officer and treasurer of the National Fertilizer Association, has been appointed consultant to the president of the Davison Chemical Corp., Baltimore.

Thomas L. Hines, general assistant manager of the Cellophane Division of E. I. du Pont de Nemours & Co., has been appointed manager to succeed the late **John E. Hatt.**

C. E. Mason has been appointed technical director of the Bristol Co. He will make his headquarters at the general offices of the company in Waterbury, Conn.

R. J. Moore has been named technical coordinator of plastics activities for the Bakelite Corp. and will be located in the New York offices of the company. Dr. Moore was formerly manager of the Bakelite Development Laboratories in Bloomfield, N. J.

Edward C. Leibig, production manager of the Technical Products Division of Corning Glass Works, has been promoted to the position of assistant to the director.

J. A. Bourne and **Margaret Curtin** have been appointed to the staff of researchers of Food Machinery Corp. in Riverside, Calif.

David E. Acker, chemical engineer, has recently joined the staff of Arthur D. Little, Inc., Cambridge, Mass.

On a wide variety of applications

AMPCO METAL

successfully resists corrosive action

Typical applications where Ampco Metal's exceptional resistance to corrosion, wear, impact, and fatigue is demonstrated daily:

- Brine pump parts in industrial refrigeration service.
- 35% sulphuric acid sludge.
- Refinery barometric condenser service (H_2SO_4 vapor).
- Bottle-washing equipment — contact with 60-80% hydrofluoric acid.
- Hot 5-7% sulphuric acid pickling equipment.
- Bottling equipment parts subject to fruit juice corrosion.
- Raw and ethyl gasoline contact.
- Saturated solution of ammonium sulphate containing by weight approximately 9% pyridene sulphate and traces of naphthalene phenol and tarry matters.
- Acetic acid and acetic formic acid combinations.
- Soap plant services (fatty acids and carbon tetrachloride).
- Plating anode hooks.

Some of the favorable qualifications for the choice of Ampco Metal in pump and valve service are as follows:

1. A complete series of aluminum bronze alloy variations from soft to hard, with physical properties closely controlled to fit specific service conditions. Available as sand or centrifugal castings, machined parts, or fabricated units.
2. High tensile strength.
3. Good hardness to resist erosion, abrasion, and cavitation.
4. Desirable physical properties at elevated temperatures.
5. Ability to mate with other grades of Ampco Metal of differing hardness without seizing and galling.

In increasing numbers, applications of Ampco Metal are being made where its superior properties prove decidedly advantageous compared to other metals.

Due to the high aluminum content of Ampco Bronzes, all surfaces, whether cast or machined, are protected with an aluminum oxide film against corrosive attacks. This film, even if injured, replaces or heals itself and is therefore on guard continuously to prevent detrimental action.

Write for bulletins giving further details on why you do a more creditable job of solving corrosion-resistance problems — at lower ultimate cost — using equipment made of durable Ampco Metal.

P-4

AMPCO Metal
The Metal without an Equal

AMPCO METAL, INC.
Department CM-5 Milwaukee 4, Wisconsin

Frank Talbot has been released by the Chemicals Bureau of WPB to take a position as industrial analyst with Defense Plant Corp. In this new work, which he began during April, Mr. Talbot will be investigating for the Surplus Property Division of DPC, the economic background in chemical enterprise against which surplus plants must be judged when considered for lease or sale.

W. E. Remmers has been elected vice president of Electro Metallurgical Co.

Earl W. Pierce has been appointed chief metallurgist of Carnegie-Illinois Steel Corp.

John P. Coyle, at present a field service consultant with OSRD, has been named winner of The Electrochemical Society's Young Author's Prize.

Charles W. Merrill, a mining engineer, has been appointed chief of the Metal Economics Division of the Bureau of Mines. He succeeds **Thomas H. Miller** who has been made assistant chief of the Economics and Statistics Branch.

OBITUARIES

Charles Donaldson Stark, Jr., 64, a mining engineer, died at his home in Greenville, Calif., April 1.

Wallace L. Caldwell, 56, president of the Alabama Asphaltic Limestone Co., Birmingham, Ala., died April 2.

Alfred V. deForest, 56, a member of the faculty of the Department of Mechanical Engineering at the Massachusetts Institute of Technology, died suddenly on April 5.

Hans Fischer, 63, a winner of the Nobel prize in chemistry, died in Berne, Switzerland.

Raymond Haskell, 66, consulting engineer for the Texas Oil Co., died in New York April 6.

Daniel During Payne, 50, manager of technical service of the sales section, Plastics Department, E. I. du Pont de Nemours & Co., died of a heart ailment April 13.

John Earl Hatt, 65, manager of the Cellophane Division, E. I. du Pont de Nemours & Co., died in Greenville, Del., April 13.

Martin H. Ittner, 74, chief chemist for Colgate-Palmolive-Peet Co., died April 22.

Robert M. Sanford, 56, manufacturing superintendent of Monsanto Chemical Co.'s plant at Monsanto, Ill., died of heart disease April 24.

Edward G. Weed, 69, president of Pyrene Manufacturing Co. of Canada, Ltd., and executive vice president of the Pyrene Manufacturing Co. at Newark, N. J., died in Toronto April 24.

Charles H. Eastwood, who had been with Wallace & Tiernan Co. for more than 21 years, died April 27.

MAPPING THE BATTLES OF PEACE

Logistics of peace, like those of war, must plan the process and flow. Human hands and brains and machines must be coordinated from rough sketch into completed job.

Bechtel-McCone's business is the designing and constructing of petroleum and chemical processing facilities with the "know-how" of experience, and the speed of specialization.

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ENGINEERS-CONSTRUCTORS
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BMC

SAFETY

Model RR50, one of more than 20 Willson Cup Goggles, meets Federal specifications for worker eye protection in chipping, grinding, riveting, sledging, snagging. The thick Super-Tough lenses of heat treated glass have high frontal impact strength. Reinforced plastic eye cups give side protection.

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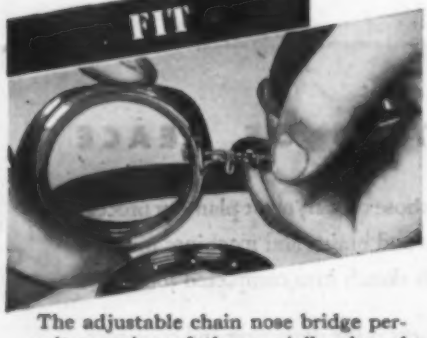

The adjustable chain nose bridge permits spacing of the specially shaped eye cups for proper fit. Adjustable headband holds cups snugly against the face. No pressure on nose, no high spot pressure on face when properly adjusted.

COMFORT

Smooth plastic eye cups with rolled edges are specially shaped to left and right eye socket contours so they always feel comfortable. Direct or indirect cup ventilation and lens ventilation assure seeing comfort and minimize lens fogging.

For help on eye protection problems, consult your Willson distributor, or write department CE-9.

GOGGLES • RESPIRATORS • GAS MASKS • HELMETS

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READING, PA., U.S.A.

INDUSTRIAL NOTES

Diamond Alkali Co., Pittsburgh, announces that William H. McConnell, formerly vice president of the Benner Chemical Co., Chicago, has joined the company as assistant director of sales. He is located in the general offices in Pittsburgh.

F. J. Stokes Machine Co., Philadelphia, has appointed Thomas Redmond sales representative for the company at Detroit with headquarters at 920 Balfour Road, Grosse Pointe Park.

United States Rubber Co., New York, has placed Howard W. Kelsey in charge of sales promotion of the general products division.

Lindberg Engineering Co., Chicago, has named Norbert K. Koebel manager of sales. He also will continue as director of research.

Crane Co., Chicago, has elected P. R. Mork executive vice president and J. A. Dwyer vice president in charge of sales.

The Trane Co., La Crosse, Wis., has placed Wm. D. Graham in charge of its branch office in Greensboro, N. C.

Olin Industries, Inc., East Alton, Ill., has made F. S. Elfred, Jr., general manager of the explosive division of the company and its subsidiaries.

U. S. Industrial Chemicals, Inc., New York, has acquired the exclusive manufacturing and sales rights of the PiB Chemical Co., makers of liquid insulation.

Electric Equipment Co., Rochester, N. Y., has purchased a building in Buffalo which will be used as a warehouse. The company also has secured warehouse and display space in the Equipment Storage Warehouse, Chicago.

Mixing Equipment Co., Inc., Rochester, N. Y., has added George R. Mellema to its staff as sales and engineering representative. His headquarters are in the Plymouth Bldg., Minneapolis.

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has elected William T. O'Connor vice president in charge of purchases.

The Girdler Corp., Louisville, has appointed Ray G. Peterson northeastern district representative with headquarters in New York and John M. Frey central district representative with offices in Chicago.

Ampco Metal, Inc., Milwaukee, has established a field engineering office at Knoxville, Tenn., and has transferred J. M. Morrison from Jacksonville to manage the new office.

Worthington Pump and Machinery Corp.,

MEETS *Your* OPERATING CONDITIONS

NO. 5422

This flexible "general-use" Taber Centrifugal Pump serves especially well in the processing industry. The pump is easily adapted to many jobs because several impellers are available for the same size casing or several size casings for the same yoke.

Oversize ball bearings, extra shaft diameter, deeper stuffing box, conservative rating...and final testing to meet your operating conditions...will keep you sold on this Taber "general-use" Pump.

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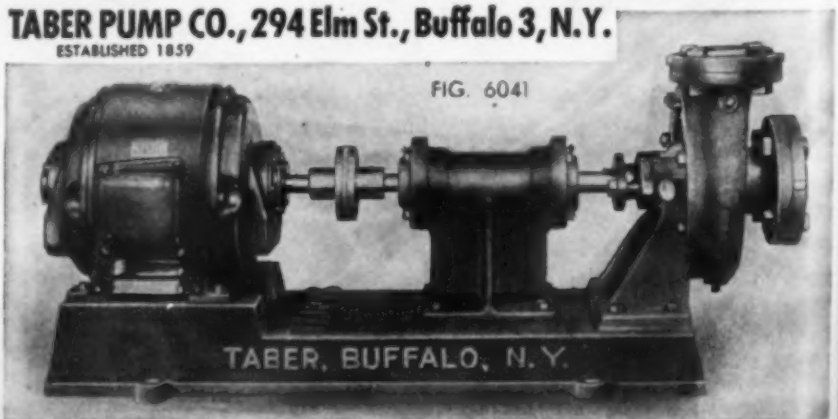
PLEASE WRITE, ON YOUR LETTERHEAD, FOR HELPFUL TABER BULLETIN CL-339

TABER PUMP CO., 294 Elm St., Buffalo 3, N.Y.

ESTABLISHED 1859



TABER PUMPS for Higher Practical Performance

MODERN DEVELOPMENTS OF GASKET RESEARCH

A BETTER JOINT SEAL FOR HIGH PRESSURE LINES

All Industry may benefit from the Petroleum Industry's solution to one of the most difficult gasketing problems.

The Ring-Type Joint, providing an all-solid-metal joint assembly, is fast finding favor in high pressure and temperature steam and chemical processing services.

Goetze V-Tite Gaskets, used almost exclusively by the Petroleum Industry for sealing ring-type joints, are the product of years of mechanical, metallurgical and chemical research.

They are available in Armco Ingot Iron or low carbon steel, 4-6 Chrome Alloy Steel, or any of the several other desirable metals or alloys; in sizes ranging from one to 80 inches in diameter and of standard oval or octagonal shape.

Every step in the fabrication of V-Tite Gaskets, from metal analysis to final inspection, is rigidly controlled to guarantee strict adherence to every detail of specifications. Extremely close tolerances are maintained to secure perfect fit.

Brinell hardness of 80-90 for Armco Ingot Iron and below 130 for 4-6 Chrome Alloy Steel, is carefully maintained by heat-treating. This assures proper flow of gasket material without damage to flange surfaces and undue stress on bolting.

Consider this better sealing method for your post-war plant requirements.

For other gasket data, interesting to engineers, write for a series of technical bulletins, based on original gasket research from the Goetze Laboratory. Please use company letterhead and mention position.

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LOWELL THOMAS Speaks on New Gasket Film

Now available to employee groups, technical societies, engineering schools and other organizations throughout the country, this new 35-minute Kodachrome film, "Only a Gasket," tells why these are the "Biggest little things" in modern Industry. Write for full information.

Goetze for GASKETS

"America's Oldest and Largest Industrial Gasket Manufacturer"

Only a Controlled Activated Adsorbent

has these 3 Primary Advantages

1 HIGHER DECOLORIZING POWER.
In commercial application Special Filtrol is proven to be two to three times as effective in its decolorization power. Refiners use only one-half to one-third as much Special Filtrol to obtain "good" color.

2 "TAILOR MADE" FOR THE APPLICATION.
Because Special Filtrol is "Tailor Made" through chemical activation, it is more effective in removing color bodies in a wide range and varying qualities of oils.

3 ABILITY TO BLEACH "OFF-QUALITY" OILS.
Poor quality oils, dark or harsh, tough waxes, low quality tallows and greases, used oils quickly yield to the activated characteristics of Special Filtrol. Refiners report that when other methods fail even the chlorophyll in crude soybean oil readily yields to Special Filtrol.

Specify Special Filtrol to insure the uniformity, cleanliness and purity so necessary to modern streamlined bleaching methods.

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A PRODUCT OF RESEARCH AND DEVELOPMENT

Harrison, N. J., has placed Carl F. Oechsle in charge of sales of Ransome Machinery Co. of Dunellen, N. J., a Worthington subsidiary.

The B. F. Goodrich Co., Akron, announces that Dean E. Carson is now director of business research, succeeding Ward Keener who recently became assistant to the president of the company.

Maguire Industries, New Milford, Conn., has purchased all the common stock of Thordarson Electric Mfg. Co. of Chicago and Antioch, Ill.

Glyco Products Co., Brooklyn, N. Y., has placed Edward Schwartz in charge of technical service throughout eastern Pennsylvania and southern New Jersey with headquarters in the company's office in Philadelphia.

Warner & Swasey Co., Cleveland, has appointed A. H. Keetch head of its newly organized sales-service department. Mr. Keetch rejoined the company after two years leave of absence on government service.

The Ohio Injector Co., Wadsworth, Ohio, announces the appointment of Joe W. Greene as general sales manager.

Hercules Powder Co., Wilmington, has named Herbert M. Wendle as the successor of George C. O'Brien as manager of the naval stores department in New York. Mr. O'Brien retired after 50 years of service with the company.

The Cooper-Bessemer Corp., Mount Vernon, Ohio, has promoted C. M. Bovard to the position of design engineer.

Foote Bros. Gear and Machine Corp., Chicago, announces that its sales representative in Pittsburgh, the W. G. Kerr Co., has moved to the Oliver Bldg.

Kieley & Mueller, Inc., North Bergen, N. J., has appointed the Jno. D. Hiles Co., Plaza Bldg., Pittsburgh, as agents in that territory.

The Selwyn Engineering Co., Chicago, has been established at 53 West Jackson Blvd., to act as manufacturers' representatives. Raymond J. Solomon formerly chief engineer of the LeVal Filter Co. heads the company.

Robins Conveyors, Inc., Passaic, N. J., has elected Thomas Robins, Jr., president to succeed Thomas Matchett who has retired from an active part in the management.

Pittsburgh Plate Glass Co., Pittsburgh, has selected I. G. Stewart to manage the new office which has been opened in San Francisco for the Columbia Chemical Division.

Westinghouse Electric and Mfg. Co., Pittsburgh, at its recent annual meeting voted to split the company's stock on the basis of four shares for one and to change the company's name to Westinghouse Electric Corp.

SELF CONTAINED 2300 VOLT OIL IMMERSED A.C. INDUCTION MOTOR CONTROL

CONSTRUCTION AND OPERATING FEATURES

1. They have an especially designed, quick-acting, heavy-duty contactor.
2. High interrupting disconnect fuses, hook stick operated.
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The simplicity, efficiency, and flexibility of this Push Button operated Control have been made possible by Rowan Engineers after thirteen years of research, and production of this type of equipment. It has been designed for Engineers whose prime thoughts are safety, continuous operation, minimum installation and maintenance cost. These starters are floor mounted and are arranged for single or group installation. They are Push Button operated; of the full voltage or reduced voltage type; arranged for indoor, or outdoor service; are of cubicle construction and are complete within themselves. *Let us have your 2300 Volt control problems.*

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THE ROWAN CONTROLLER CO., BALTIMORE, MD.

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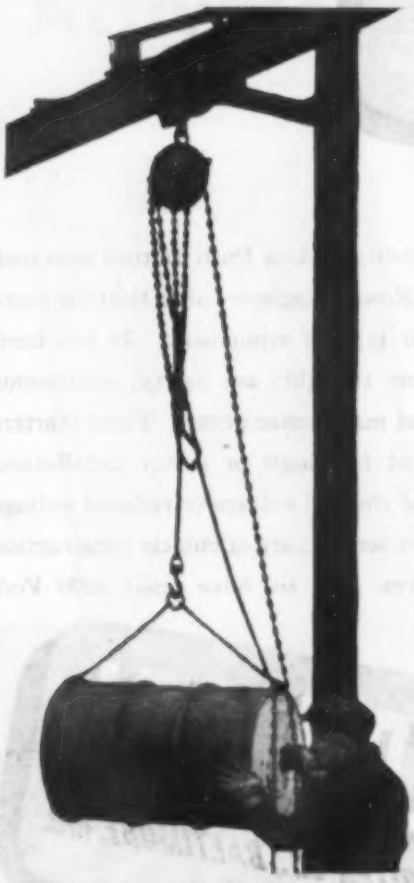

unload faster
move loads easier

The multiple gear Reading Hoist used on this job gives maximum speed of load movement.

The sealed-in-oil gear unit permits operation outdoors with complete safety. Other models of Reading Hoists are available to solve materials handling jobs where lifting power is most important or where easy portability of the hoist is needed. Capacities range from ¼ to 20 tons for trolley, hook, post or jib mountings.

See your nearest distributor or write us about your materials handling problem and we will be glad to make a recommendation.

READING CHAIN & BLOCK CORPORATION
2105 ADAMS ST., READING, PA.
CHAIN HOISTS • ELECTRIC HOISTS
OVERHEAD TRAVELING CRANES

READING HOISTS

(Continued from page 132)

original inoculation—approximately 80-90 percent of the fermentation is completed in the fermenting vessel and the balance is completed in the beer well.

This fermentation system reduces the time from a normal of 48-72 hr. to 10 hr. Thus, considerably less space and equipment is required. Furthermore, the need for yeasting operations is practically eliminated since the fermenter can be cooled and held over long periods of time. A small laboratory model was inoculated over six months ago and at the time of this writing is still in operation with no additional yeast inoculations. It has been cooled and held for periods of several weeks with success. A pilot plant has successfully demonstrated that the process is practical but as yet no large plant installation has been made. Research indicates that the fermentation cycle can be reduced still more.

COAL TAR INTERMEDIATES

JOHN M. WEISS
John M. Weiss & Co.
New York, N. Y.

THE MANUFACTURE of coal tar intermediates, in so far as the great majority of products is concerned, has been entirely by batch processes. So long as the use of intermediates is mainly for the production of dyestuffs and medicinals, the tonnage requirements are not likely to become of sufficient size to warrant the development and adoption of continuous processes.

In a few cases, where utilization outside of the dyes and fine chemical products has very largely increased the tonnage demand, continuous or semi-continuous processes have been adopted. In the main, however, especially since the same equipment can often be used for several products, batch processes prove more flexible, and operate with as low costs as could be expected with a continuous system.

Without question, the coal tar base intermediates which have developed to the largest tonnage scales are phenol, aniline, phthalic anhydride, and styrene, and the tonnage development, except in the case of aniline, has been overwhelmingly outside the dyestuff field. Synthetic plastic and rubber production have engendered the large tonnage demands.

Styrene is synthesized by methods of alkylation and controlled thermal treatment which parallel similar developments of the petroleum industry and are throughout typical continuous processes except for surge storage between steps.

Phthalic anhydride production is also continuous. The type of process used, the catalytic gas phase oxidation of naphthalene, is inherently continuous in nature. However, the final distillation and purification of the crude product is universally a batch process. The size of operation, even though very great from the standpoint of the initial chemical transfer, is not of a scale that would be considered

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Timken Seamless Tubes are made in intermediate alloy, alloy and stainless steels in electric furnace or open hearth grades. They have excellent weldability and a high degree of ductility which makes for rapid and easy installation.

When you plan new construction or replacements specify Timken Seamless Tubes. They are your assurance of receiving maximum tube life per dollar invested. Steel and Tube Division, The Timken Roller Bearing Company, Canton 6, Ohio.

Data on a large number of steels for high temperature service are available by writing a request on your business letterhead.

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"BALANCED WET BULB" TEMPERATURE CONTROL

U. S. Patent Re-Issue No. 22,553

CONTROL OF TEMPERATURE IN LIQUIDS and GASES

HELPS INCREASE PRODUCTION

U. S. Patent Nos. 2,296,940 and 2,321,933. Re-Issue No. 22,553—Other Patents Pending.

● During the first year of the war, hundreds of installations of the NIAGARA AERO HEAT EXCHANGER were made to assist in war production in various industries.

Many of these installations, which were made primarily because they offered the advantage of saving the cost of cooling water, now show an extra value of great importance in increasing plant production.

Production is increased in three ways: (1) By preventing rejections (2) By permitting quicker starting of every production batch at the correct temperature (3) Your production is faster, due to your *constant* temperature.

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large from the standpoint of distillation practice. A plant making 20,000,000 lb. of phthalic anhydride per year only has to have a distilling capacity of about 6,000 gal. per day.

Aniline processes divide into two types. The one where chlorobenzene is treated with ammonia at high pressure is well adapted for continuous operation since reactants and products are liquid. The second, based on nitrobenzene and reduction by iron filings, a solid, does not fit so well into continuous operation and batch processes are the rule. The plants employing this method also make much smaller quantities of toluidines and xylidines for which the same equipment can be used as with aniline, an advantage which would be lacking in a continuous system.

Phenol is made by three types of process. In two, which involve the hydrolysis of chlorobenzene with caustic soda or with water, continuous operation is common practice. With the other, sulphonation of benzene and fusion of the sulphonate with caustic soda, batch processes are almost universally employed. Some steps have been made continuous—for example, in one plant a continuous fusion has been employed and in another, the final dehydration and distillation is carried on in a continuous still. In no case, however, are the processes continuous as a whole and in all cases, the majority of the operations making up the complete process are batch.

In general, the production of intermediates does not appear to present a rapidly developing field for the economic use of continuous processing. Such development can only be expected as the use of specific products expands in fields outside of the rather restricted tonnages of dyestuffs and medicinals.

SYNTHETIC RUBBER

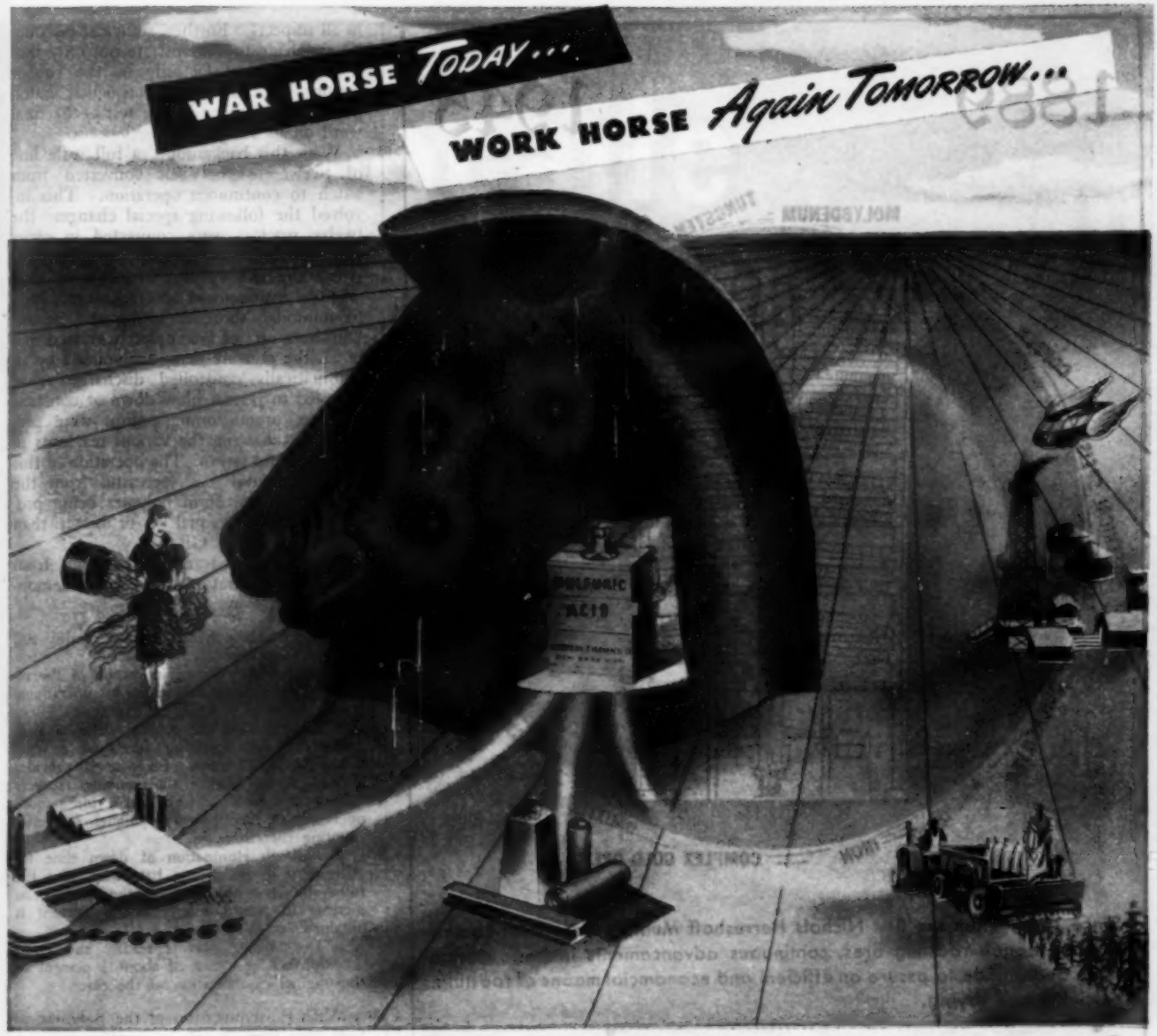
A. J. GRACIA

Manager, Chemical Engineering Division
Goodyear Tire & Rubber Co.
Akron, Ohio

By the time government "standard plants" were built and ready for equipment installation, continuity of process for synthetic rubber manufacture had been established in all but the starting or polymerization step. That is to say, from the moment a sufficiently reacted polymer in latex form was obtained, to the time a finished bale of rubber emerged from the boxing operation, the process was a continuous one. Recovery of unreacted monomers, blending and coagulation of the latex, dewatering, grinding, drying and baling of the rubber crumb were all series and continuous operations. Thus, nothing was more logical, or desirable, than to seek to extend the continuity of the process to include polymerization.

The critical rubber situation would not permit a wait for the development of a satisfactory method of continuous polymerization, with the result that batch polymerizers were installed in all plants. Thus any practical application of the continuous principle subsequently would involve utilization of the then installed batch reactors.

Meanwhile, pilot plank work indicated that GR-S could be produced continuously to meet Rubber Reserve Co. specifications



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Sulfuric Acid is aptly named "Industry's Work Horse" for probably no other chemical compound has a greater number of commercial applications. Each of the product's properties leads to a long chain of uses . . . in war . . . in peace.

With Industry's demand for this basic chemical growing constantly, General Chemical Company is now creating new sulfuric acid facilities at strategic locations to help provide for urgent regional requirements.

General Chemical has been one of the nation's important producers of sulfuric acid since the turn of the century when the Company pioneered in America with the Contact Process for manufacturing pure, high strength acid. Today's new developments at Hegewisch, Ill.; Cleveland, Ohio; East St. Louis, Ill., and Newell, Pa. are one more example of *General Chemical Sulfuric Acid serving the nation's needs—now as in the past.*

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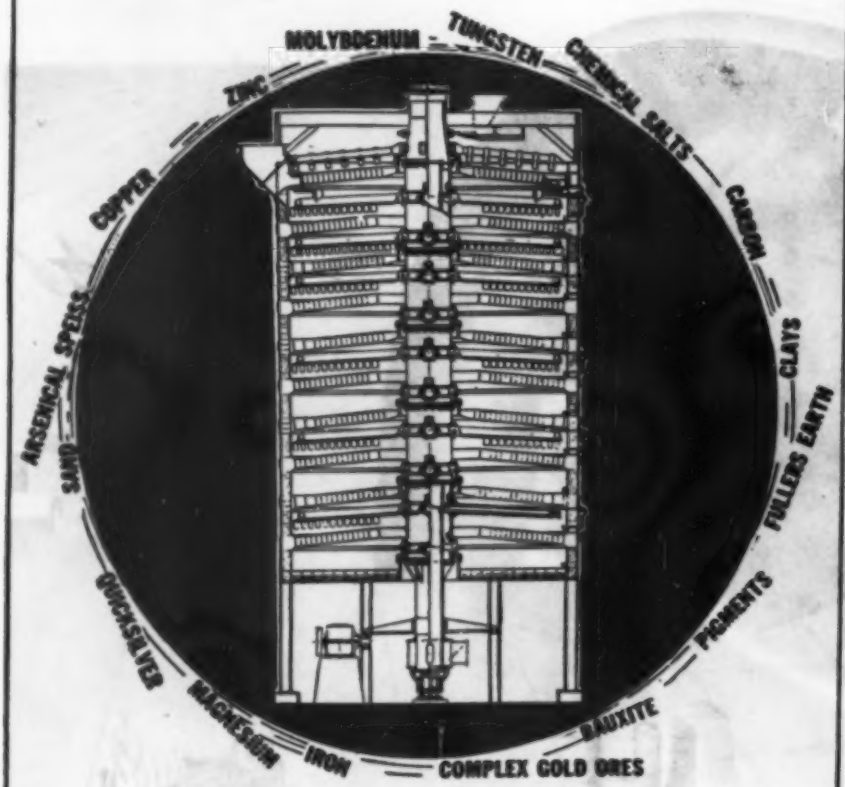
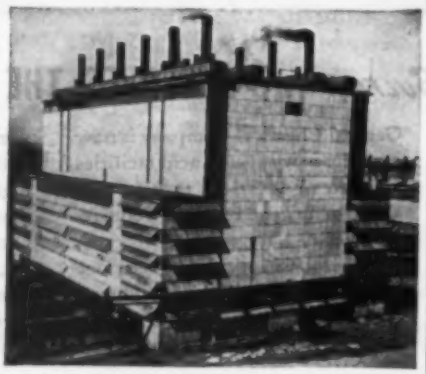
1889 1945



Since 1889, when the first Nichols Herreshoff Multiple Hearth air-cooled furnace began roasting ores, continuous advancements in basic design have been made to assure an efficient and economcial means of roasting, calcining and drying.

Given above are a few of the many materials thermally processed in Nichols Herreshoff Multiple Hearth Furnaces with outstanding success.

Nichols engineers can focus a wealth of experience upon your particular problem of roasting, calcining or drying. Thousands of furnaces have been installed, scores of materials processed. This fund of knowledge is invaluable. Consult a Nichols engineer to secure the benefit of this long experience in construction and design.



Above is one of the largest vital war material plants, designed by Nichols, for roasting limonite and serpentine ores for the economical production of NICKEL.

NICHOLS

ENGINEERING & NERCO RESEARCH CORP.

60 WALL TOWER BUILDING
NEW YORK 5, N. Y.

UNIVERSITY TOWER BLDG.
MONTREAL, P. Q.

in all respects. Further, sufficient polymer was so made to demonstrate not only that it processed satisfactorily in the rubber factory but also that it equalled batch polymerized rubber in tire tests—the final word on its acceptability.

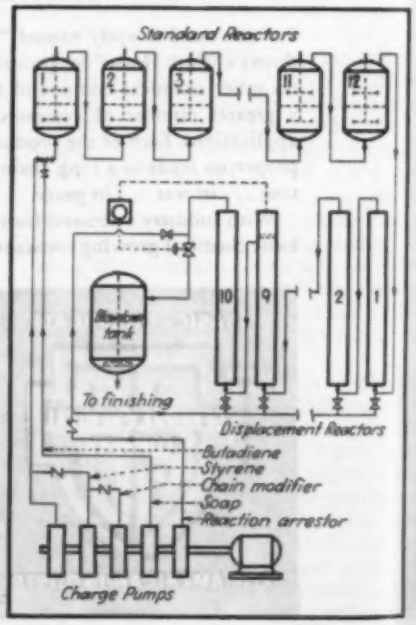
With this background, a full scale line of twelve reactors was converted from batch to continuous operation. This involved the following special changes: the twelve reactors were connected in series and horizontal baffles were installed between the two agitator elements of each reactor; displacement reactors were added to minimize short circuiting and permit "finishing up" of incompletely reacted material, the pressure being maintained by an automatically controlled discharge valve, installed to permit blow down at constant pressure; proportioning pumps were provided for charging the various reactants in their required ratios. The operation of this continuous unit was successful from the start, with a uniform polymer being produced that was equal to or better than regular batch-wise GR-S.

Outstanding advantages accruing from continuous operation have been demonstrated as follows:

1. A uniform polymer of good quality and improved processability is produced.
2. Savings are effected in certain of the reactants, in maintenance and in operational labor.
3. Peak demand for cooling water, a limitation in batch operation, levels off in continuous polymerization. Likewise it provides a more uniform load on the monomer recovery equipment which in turn makes for smooth operation of this unit with higher recoveries resulting therefrom.
4. Through elimination of down time for charging and discharging batchwise, plus the full volumetric utilization of the reactors, an increase in plant capacity of 50 percent is obtained.
5. The change over is readily and easily accomplished at a cost of about 1 percent of the original capitalization of the plant.

With the conversion of the polymerization step from batch to continuous, the

Continuous polymerization of GR-S



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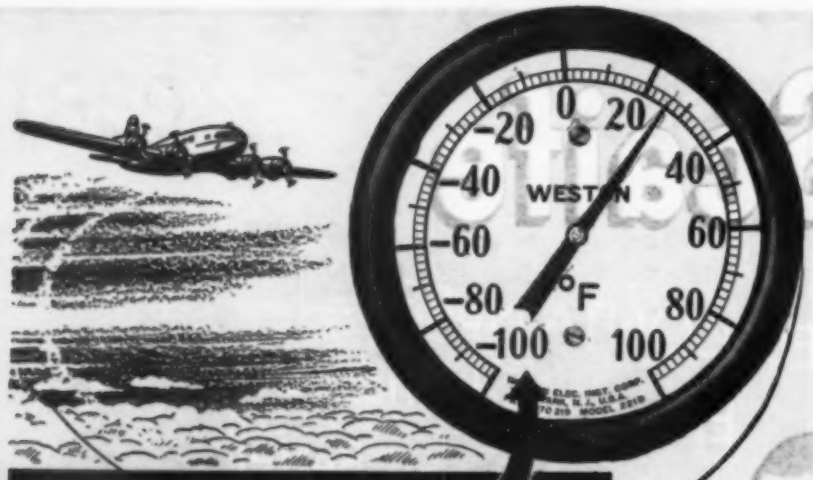

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This wide-range stability stems from WESTONS all-metal construction, which eliminates the need for liquids, gases, or involved mechanisms. It also provides unusual resistance to vibration, shock and mechanical abuse . . . as proved by many thousands of WESTON thermometers in service throughout the years. Literature gladly furnished on request. Weston Electrical Instrument Corporation, 590 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston all-metal thermometers are available in types, sizes and ranges for most industrial needs.

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whole GR-S synthetic rubber production operation is endowed with a continuity that suggests the extension of this principle throughout the wide and varying field of production of synthetic rubbers, synthetic latices and plastics.

EDIBLE OILS

ALAN PORTER LEE
Alan Porter Lee, Inc., Engineers
New York, N. Y.

EXTRACTION of oils from nuts and seeds is an ancient art, practiced by the Chinese and the Mediterranean peoples literally centuries ago. Primitive methods utilized some form of mechanical grinding or pressing, the power for which was furnished by men, horses, or cattle.

First mechanical advances were found in application of the lever and the screw to the pressing operation for multiplication of power. These were naturally succeeded by the hydraulic press, which has for a century or more been standard equipment for obtaining oil from seeds. The development of hydraulic pressing has involved the use of various types of auxiliary preparation equipment and in modern hydraulic mills practically all of this auxiliary equipment has been of continous type. This has been particularly true of mills handling flaxseed and cottonseed, but in the best of these the hydraulic press itself has retained its batch or intermittent characteristics, requiring manual loading, a time interval for pressing and manual unloading.

During the past forty years or so the mechanical worm or screw press as first developed by Anderson has attained considerable popularity as the best-known means of making the oil mill truly continuous and many mills throughout the world have adopted this type of equipment.

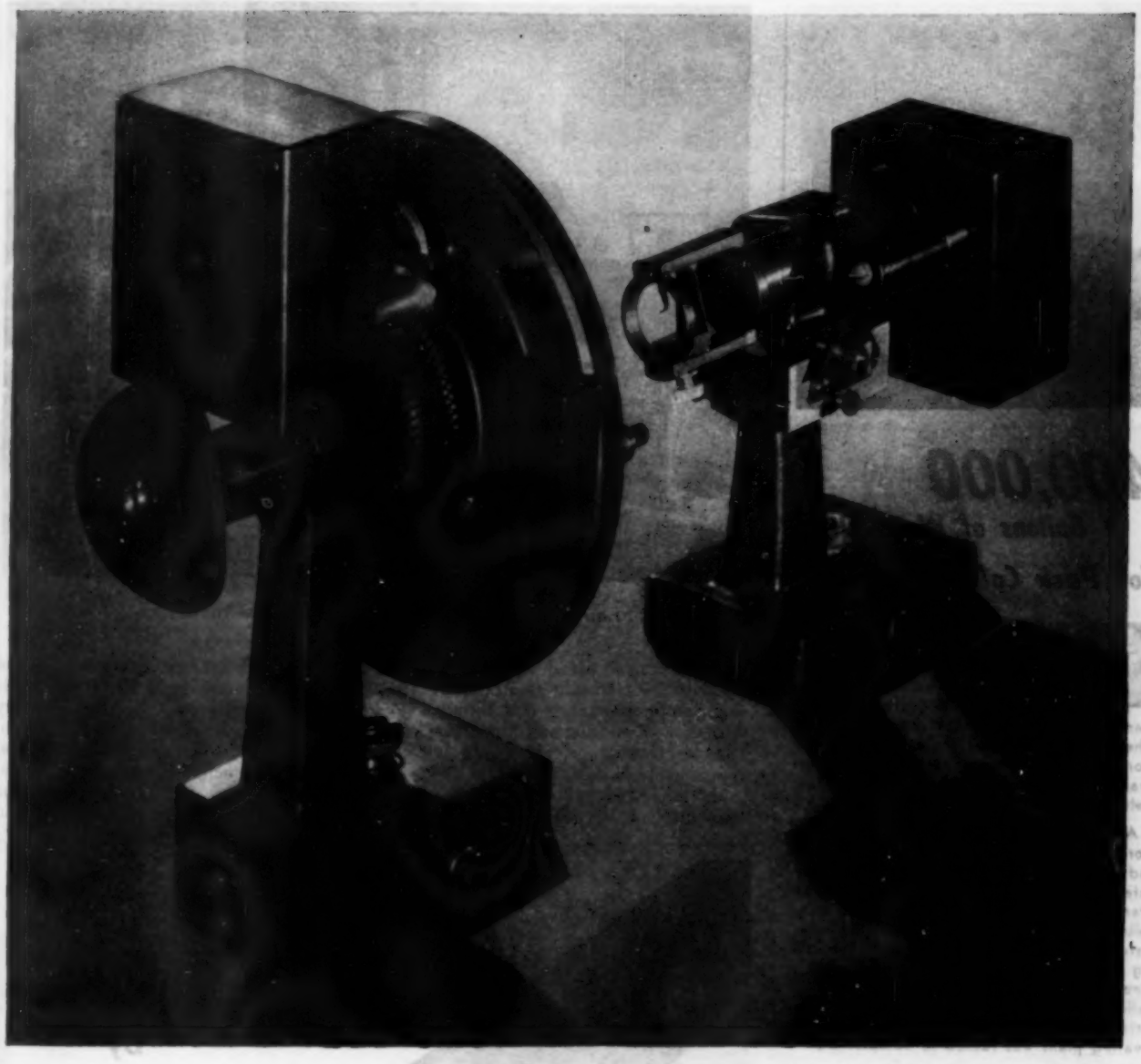
All mechanical pressing equipment, however, is limited in function by the fact that a relatively large proportion of the oil contained in the seeds pressed is not recovered but remains in the press-cake.

The alternative method of extraction of the oil by suitable solvents has been practiced for more than fifty years, generally in batch procedures. During the past ten or fifteen years great improvement in the qualities of petroleum solvents has stimulated the design and development of continuous solvent extration plants.

A number of large installations have been made in Europe and in this country. Continuous solvent extraction has been successfully applied to most types of oil-bearing seeds and nuts and will undoubtedly be applied to all. It may be considered a certainty that the advantages of continuous solvent-extraction methods, which are to be found in lower operation costs and increased value of products yield, will result in continued wider application of this procedure during the postwar era.

REFINING

The refining of edible oils involves usually three and in some instances four major steps. The primary three are: Neutralization of free acid, bleaching, and deodorization (steam distillation of odorous substances). The fourth step is applied to cottonseed oil and other oils which con-



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And then in 1941 the situation became even more critical. Both resident and college use had to be cut to the absolute minimum. By vote, the citizens approved an ordinance granting Layne-Western Company a franchise for taking over and operating the water system. Two new Layne Well Units consisting of Layne Gravel Walls and vertical turbine pumps, capable of producing 400,000 gallons of water daily, were immediately installed. A modern iron removal and water treating plant was rushed to completion.

Today, Park College and the City of Parkville have a thoroughly modern and highly efficient water system with a capacity far greater than their needs. The water is clearer and finer than ever enjoyed before . . and all at a tremendous annual saving to the College.

For further facts about Layne Water Systems, Layne Turbine Pumps and Layne Services, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

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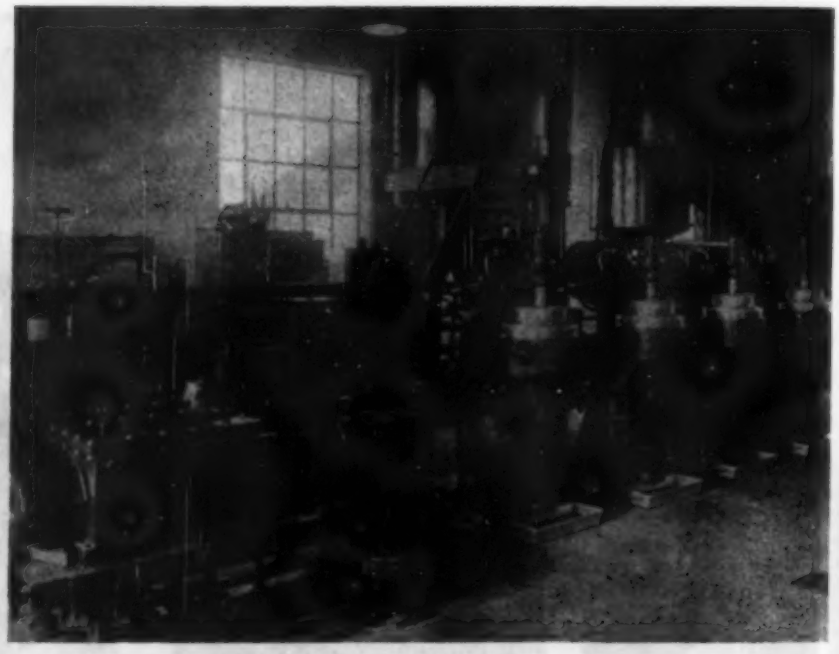

Equipment for continuous refining of cottonseed oil

tain considerable percentage of high melting glycerides known as stearines. This step comprises chilling and filtration for separation of stearine and production of a salad or cooking oil which will not become cloudy in cold storage.

In the past ten years the neutralization step, involving the addition of alkali and separation of soap formed in neutralization of the free fatty acids, has been made generally continuous in this country through utilization of high-speed continuous centrifugal machines and proportioning equipment. Entirely new continuous procedures for this operation are in the course of development and it can

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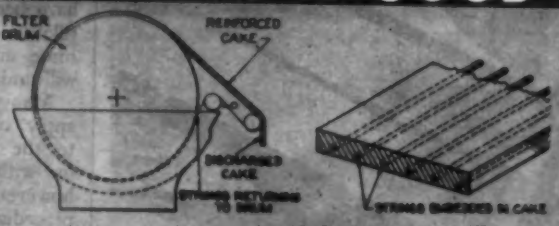
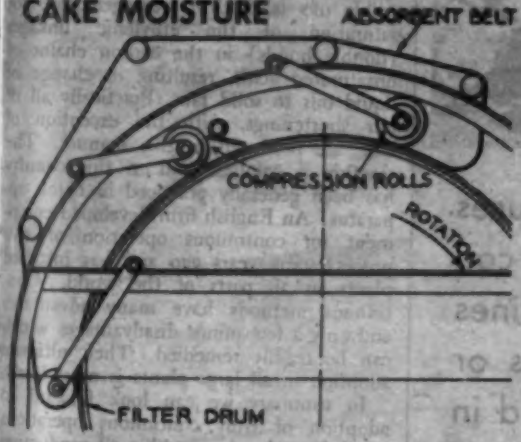


STRING DISCHARGE

FE Continuous Rotary Vacuum Filters feature the string discharge that *lifts* the filter cake from the revolving drum in a continuous, uniform sheet. Does away with scrapers and "blow-back." No wire winding needed to hold the cloth in place, and no severe mechanical strain or abrasive wear on the cloth.

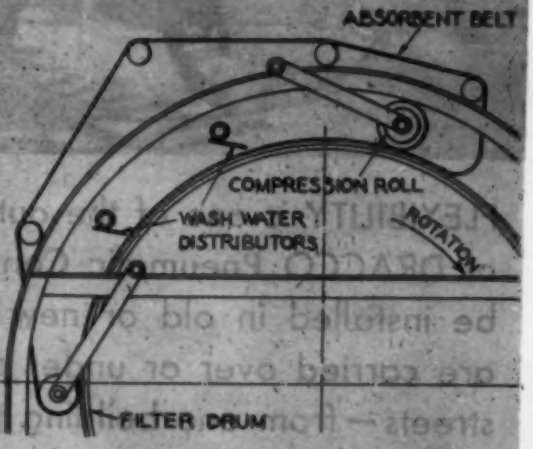
LOWER CAKE MOISTURE



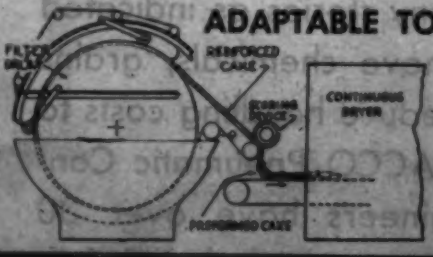
FE Compression Mechanism squeezes 2 to 6% more moisture out of the filter cake. It also reduces vacuum power requirements by closing up cracks that may occur in the cake. As shown above, it consists of segmented compression rolls that ride on a cotton duck compression belt on the exposed portion of the revolving filter drum.

BETTER WASHING

Less residual impurities, and better recovery of solubles in the filter cake are results with the FE Chemical Washing Filter. During the long washing arc, the filter cake is thoroughly flooded with wash water. All cracks in the cake are closed up so that the washing is uniform. Thorough dewatering gives you a clean cake with low moisture.



ADAPTABLE TO CONTINUOUS DRYERS



FE filters can be arranged to deliver filter cake that is preformed for fast, straight-line flow of material to any type of continuous dryer. Ask for details of FE Cake Scoring Device.

Filtration Engineers Inc. will be glad to show you many other ways FE Filters can improve your continuous filtration. Call on us.

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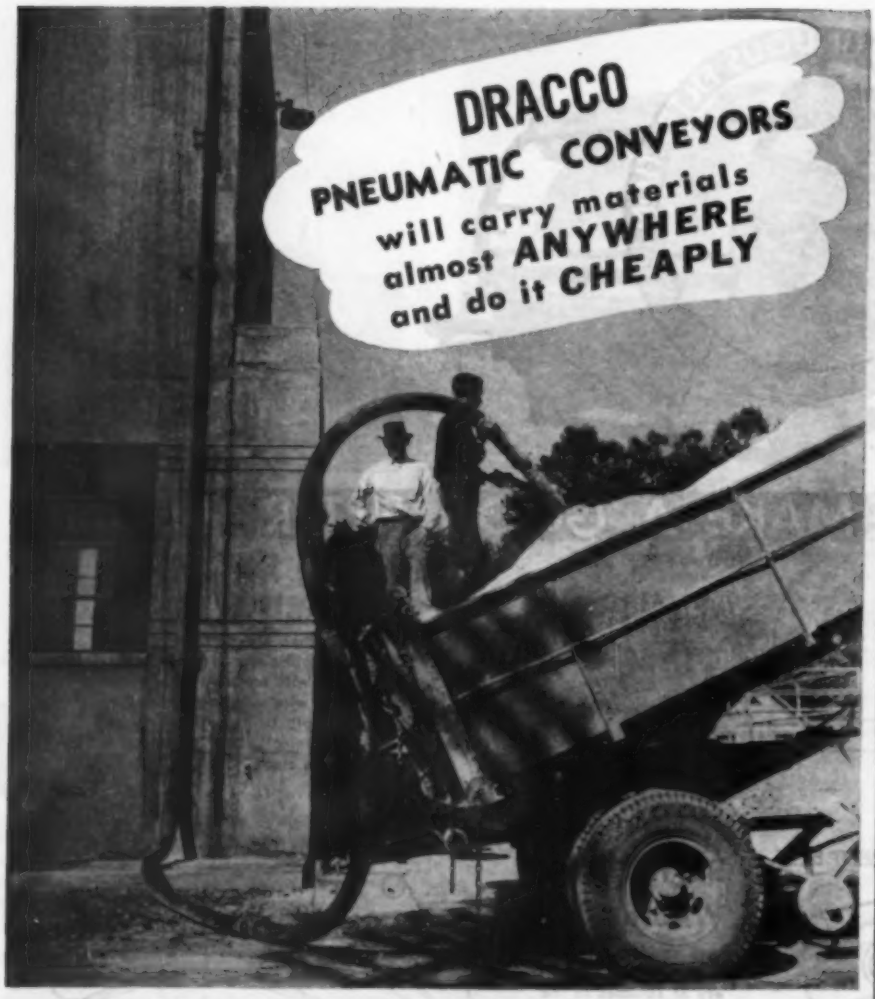

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DUST CONTROL EQUIPMENT
PNEUMATIC CONVEYORS • METAL FABRICATION

be safely predicted that batch operations of this nature will be entirely obsolete in the era which we are now entering.

The color improvement step in refining has been heretofore practiced generally as a batch operation, involving agitation of the oil with adsorbents such as fullers' earth and activated carbon. A minor number of processors have applied continuous methods to this procedure using dry proportions and alternating filter presses. Continuous filters have not been successfully used. The color improvement step using adsorbents will undoubtedly be installed as a continuous process in future refineries of important size, but this type of decolorization is likely to be abandoned entirely in favor of more economical methods as the science of oil refining progresses.

While deodorization of edible oils by batch steam distillation of the odorous substances in vacuo has been developed to a state of comparative perfection, attempts have been made to apply continuous distillation methods to this procedure with some success. The continuous procedure will undoubtedly gain ground.

Many attempts have been made to apply continuous crystallization methods to the separation of stearine from oils, but with indifferent success. It is believed, however, that introduction of specialized procedures which will handle the problem in a truly continuous manner can be expected in the very near future.

An important operation in treatment of edible oils is that of hydrogenation, for saturation of the ethylenic linkages (double bonds) in the carbon chains of unsaturated acids, resulting in change of liquid oils to solid fats. Practically all of our shortenings, with the exception of lard, are produced in this manner. The reaction is catalytic and in this country has been generally practiced in batch apparatus. An English firm developed equipment for continuous operation of this process some years ago and has installed plants in all parts of the world. Continuous methods have many advantages and only a few minor disadvantages which can be readily remedied. Their ultimate adoption in all large plants is most likely.

In summary we can look forward to adoption of truly continuous operations in all departments of edible oil production and refining. The consequent reductions in operating costs and inventory investments will be considerable, but standardization and improvement of quality will likewise be major resulting gains.

ELECTROPLATING

JAMES A. LEE
Managing Editor
Chemical & Metallurgical Engineering

THE CONTINUOUS electroplating of metals, like synthetic rubber production, had made a start before the war, but the large-scale commercial developments have taken place since Pearl Harbor. Today, installations of the several continuous electroplating processes represent an investment of $60,000,000 to $75,000,000 in plants throughout the country.

It is estimated that the yearly saving of tin resulting from the use of the electrolytic processes is 6,000 tons. Electroplating

For ACIDS

Hot Liquids

Corrosives AND MILD ABRASIVES

This is the pump that is delivering peak-production loads in hard-driven chemical plants all over the country. It's a pump without a stuffing box—the pump that's free from stuffing-box troubles. No rubbing contact. 10- to 1,000-G.P.M. capacities, 15- to 125-ft. heads and higher. Buy WILFLEY for increased production without interruption.

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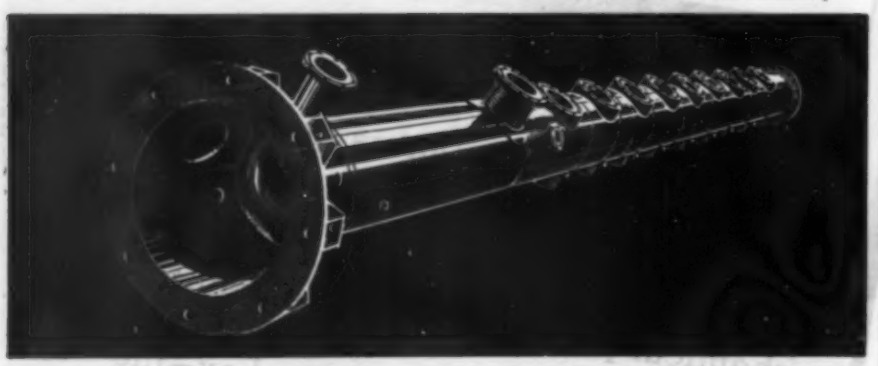

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API ASME U-68 U-69 Codes · Stress Relieving · X-ray

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deposits are much more uniform in thickness than the former hot-dip coatings. The processes lend themselves to more accurate control, hence, the new method applies coats in the exact thickness required to meet specifications which may be varied according to the use for which the product is designed.

By the high-speed, continuous processes 10-ton coils of 36-in. steel strips are coated with tin at a rate of 500 to 1,000 ft. per min. Copper, zinc, brass, and nickel are being continuously plated at rates in the neighborhood of a few hundred feet a minute.

Electroplating processes offer further interesting possibilities when restrictions on certain scarce metals are lifted. Because the sides of the strip may be coated alternately it is possible to tin one surface and apply an entirely different metal to the other. This is a development of electroplating that may have important applications in the postwar era. It is quite possible that the tinned steel for all "general line" cans, those used for products like tobacco which do not require thermal treatment for preservation of the contents, will be coated by electroplating. It will also be used for non-corrosive foods.

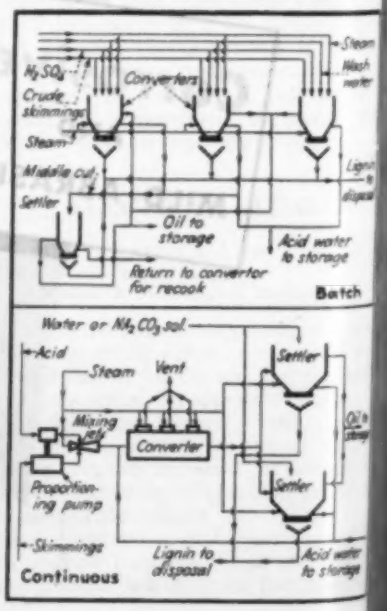
TALL OIL

K. W. COONS

Head, Dept. of Chemical Engineering
University of Alabama, University, Ala.

WHILE crude tall oil from black liquor has been commercially produced only by batch methods, the process may well be operated continuously. A number of features which make it suited for continuous operation are: (1) Availability of ample supplies of crude black liquor skimmings that are continuously produced. There is no seasonal supply requiring storage of raw material. (2) An excess of acid is required, yet the control of this excess is not so critical that slight variations in the raw materials would throw a continuous operation out of balance. (3) Recovery of

Batch and continuous production of tall oil from black liquor



This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.
No valves, pistons, or vanes.
No internal lubrication.
Low maintenance cost.
Saves floor space.
Desired delivery temperature automatically maintained.
Slugs of liquid entering pump will do no harm.
75 pounds in a single stage.

NASH ENGINEERING COMPANY
325 WILSON, SO. NORWALK, CONN.

This man can help you gear your plant for post-war

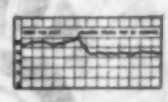
The Baker Material Handling Engineer is at your service to help you meet postwar demands for lower production costs, increased plant capacity and improved working conditions. His intimate knowledge of inside transportation problems—in plant, warehouse, shipping or receiving platforms—enables him to evaluate your complete handling set-up and recommend the proper equipment to achieve objectives listed below, for present or post-war needs.

INCREASED PLANT CAPACITY

Baker trucks can help you multiply the value of plant floor space by tiering material two or three high (or higher), by storing bulky dies or other material in yards or remote areas, by keeping materials moving and machines running for most efficient production.

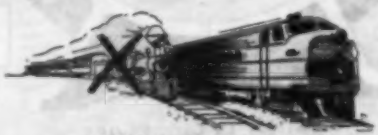
GREATER MANPOWER EFFICIENCY

Handling materials faster, handling bigger loads, using one man (or woman) with a power truck to do the work of 6 or 8 with hand trucks, getting more out of skilled labor by cutting idle machine time—these are a few of the ways in which Baker Trucks can improve manpower efficiency.



LOWER PRODUCTION COSTS

Since handling of material is not strictly a production operation, it offers one of the best possibilities for savings in overhead cost. Rent costs, machine and labor costs, loading (and unloading) costs, spoilage costs, accident costs—all can be cut by proper use of Baker Trucks.



FASTER DELIVERIES

Streamlining production and movement of material with Baker Trucks can move up delivery dates. Shipping and receiving in "unit packages" on skids or pallets means less damage in transit. Faster loading and unloading and better warehouse handling are also important factors.

IMPROVED PLANT SAFETY

Material Handling accidents account for approximately 5 million working days lost annually—about ¼ of the total. Eliminating the handling of heavy objects, overloading hand trucks, improper stacking, and overhead dangers by the use of Baker Trucks, can go far toward reducing this waste.

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Plant and production managers, traffic managers, superintendents, purchasing agents and any others concerned with material handling will find the new Baker Catalog No. 52 a valuable reference.

Baker INDUSTRIAL TRUCKS

products and byproducts is adaptable to continuous or semi-continuous operation. (4) Economy in heat and power may be effected by continuous operation and appropriate exchangers.

Certain conditions exist, however, which must be carefully considered and taken care of no matter what process is used. Some of these are: Presence of noxious gases, excess acidity in the acid water bottoms which requires acid recovery and introduces corrosion problems, presence of sodium sulphate in the acid water, separation and disposal of lignin, and possibility of heat recovery.

A comparison of the batch process and a proposed continuous method will bring out some interesting possibilities. In both cases the material flow per 24 hr. will be the same and is as follows: Skimmings, 100,000 gal.; H_2SO_4 (60 deg. Bé.), 98,000 lb.; steam, 125,000 lb.; tall oil, 350,000 lb.; lignin, 70,000 lb.; Na_2SO_4, 126,000 lb.; acid water, 50,000 gal.

BATCH

Crude black liquor soap skimmings are treated with 60 deg. Bé. H_2SO_4 in wooden, brick lined or carbon lined vats from 4,000 to 30,000 gal. capacity depending upon the production requirements of the plant. In most cases heat and agitation are supplied by direct steam blown into the mass. During this steaming period the liberated gases (H_2S) must be vented to prevent injury to workers.

When the reaction is complete and the mass allowed to settle, there separates to the top an oily layer of tall oil, at the bottom a layer of water containing excess acid and dissolved sodium sulphate; while, as a middle layer there separates lignin and the wood pulp that was entrained in the soap. When processing, the top layer of clear oil is drawn off and sent to storage. The acid water is drawn off and sewered or sent to black liquor storage tanks. The bottom of the oil layer is then drawn off together with some acid water and lignin and sent to a secondary settler. Here the oil and water are properly disposed of and the middle layer sent back to the converters to be reworked. The lignin remains in the converters until it interferes with operations. The unit is then shut down and the lignin removed.

CONTINUOUS

Crude skimmings are passed countercurrent to the hot oil thereby being partially heated. Passing through a proportioning pump they are then mixed with acid and steam in a Duriron or carbon mixing jet. In the reaction chamber, which provides 2-hr. retention time, the mass is kept hot and mixed by jet type steam mixers. This vessel is adequately vented to a stack or through water scrubbers and then under the boiler grates. In this unit are combined the operations, of mixing, reaction, and heat transfer. The effectiveness of reaction with resultant quality of finished product is dependent on mixing. In the continuous unit, steam jet type ejector mixers will adequately provide mixing, reaction conditions, and heat transfer to the reaction mass.

From the reaction vessel the reaction mass passes to a semi-continuous stage of the operation. Two settlers are provided to separate the oil from the acid water and the middle lignin layer. Formation of the three layers is rapid and a settler may be run until nearly full of lignin. The stream is then cut to the other unit and the lignin washed with hot water, the oil floated off, the acid water being drained to storage. A second alkaline wash with soda ash or black liquor neutralizes the lignin which may then be dumped and washed out through the large doors provided in the settlers for this purpose. The unit is then ready for

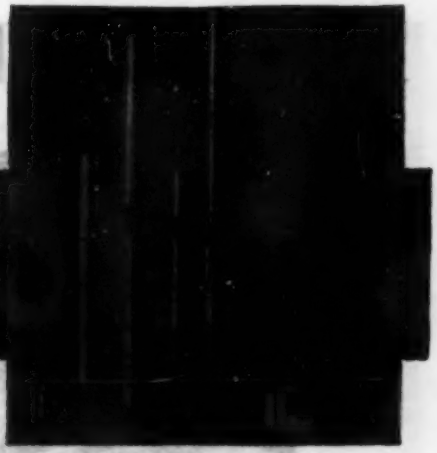
ALOYCO STAINLESS STEEL VALVES

SOLVE DIFFICULT CORROSION PROBLEM AT COASTWISE PETROLEUM COMPANY

ALOYCO VALVES PREVENT STILL SHUTDOWN

To prevent shutdown of the distillation operation and avoid servicing in an inaccessible location, Aloyco Valves are installed in heat exchanger manifold since they are practically immune to welds encountered.

Note non-fouling double-disc wedge. Free to rotate, it provides drop tight closure. Valve fabricated of stainless steel, even to bonnet bolting.



If you handle corrosive fluids, you can benefit from the experience of Coastwise Petroleum Company's Goodhope, Louisiana Plant. Before they began to use Aloyco Stainless Steel Valves, valve life on their Benzol Treaters was only a few months with acid, less with alkali—making repair charges high, causing frequent service interruptions. Finally, to withstand the effluent which varies from sodium sulphate, benzene sulphonic acid, sulphuric esters, etc. to soda and acids, they chose Aloyco Valves fabricated of Aloyco 20.

After one year of continuous service, these Aloyco Valves are still on the line and give promise of remaining there indefinitely. This is but one of the many good records Aloyco Valves have made in resisting corrosion. Investigate what they can do in your plant. Write us today.

Other alloys available: 18-8S, 18-8SMo, the higher Chrome-Nickel series, Worthite, Hastelloy, Monel, Pure Nickel and others.

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Stainless Steel VALVES and FITTINGS

GATE VALVES • GLOBE VALVES
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LEVER THROTTLE GATE VALVES
TANK VALVES • SCREWED FITTINGS
FLANGED FITTINGS
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ALLOY STEEL PRODUCTS COMPANY, INC., 1301 West Elizabeth Avenue, Linden, N. J.

LARGE DIAMETERS

Buell's assurance of
HIGH EFFICIENCY, LOW MAINTENANCE, LONG LIFE

THE DECIDED ADVANTAGES of Buell's large diameter cyclones, made possible by the patented "Shave-Off", definitely reflect industry's growing preference for Buell (van Tongeren) Dust Recovery Systems.

Large diameters make possible a collection operation with low centrifugal force and permit construction of extra thick steel. This accomplishes two things: minimum abrasion and long life. *Large diameters* afford large dust outlets, making clogging practically nil. *Large diameter* cyclones have the added advantage of handling a given gas volume with fewer units.

Engineers who look to low cost up-keep and continuous operation as prime requisites in dust recovery should give these factors serious consideration.

BUELL FEATURES

SHAVE-OFF
LARGE DIAMETERS
EXTRA-STURDY CONSTRUCTION
CORRECT HOPPER DESIGN
SPLIT-DUCT MANIFOLDS
INSIDE WELDS GROUND SMOOTH

RESULT IN

HIGH COLLECTION EFFICIENCY
LESS FAN BLADE WEAR
LOW DRAFT LOSS
LOW POWER CONSUMPTION
HIGH TEMPERATURE RESISTANCE
UNLIMITED CAPACITY
NO MOVING PARTS
FREE DUST FLOW

PRODUCE

HIGH EFFICIENCY
LOW MAINTENANCE
LOW OPERATING COST
LONG LIFE
NO CLOGGING

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DUST RECOVERY SYSTEMS

Engineers and plant executives are invited to write for Buell's factual 28-page book:
"The van Tongeren System of Industrial Dust Recovery"

BUELL ENGINEERING COMPANY, INC.
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DESIGNED TO DO A JOB, NOT JUST TO MEET A "SPEC"

refilling. No trouble has been experienced with the accumulation of a heel of oily lignin that could not be handled in the equipment.

The acid water may be charged directly to the mill black liquor storage where it is neutralized and serves to build up the sulphate content, or it may be neutralized and sent to evaporators where salt cake is produced. In either case the heat content is utilized. The flow streams are noted on the flow sheet.

Compared to batch operation the continuous set-up will generally cut costs. Buildings for any given batch production will house continuous equipment with double the capacity of the batch operation. Smaller pumps can be used. There will be less wear and tear on equipment where conditions are kept constant. The heating and cooling and violent agitation in the batch type converter vats tears them up so that the life of a wooden vat is less than 18 months. Continuous operation can be subjected to automatic and recording control instruments that remove the trouble due to normal human variations. The continuous unit can well be operated by one man whereas the batch system requires two men per shift.

Outstanding in the economy of the continuous operation will be a saving in power plant costs. Roughly the same amount of steam is used per day in each instance. However, the batch operation uses the equivalent of 500 hp. of boiler capacity for 1 hr. and then is down for 4 hr. A change over to continuous operation would smooth out this steam demand and make possible the use of 100 hp. of installed boiler capacity. Such a situation will also greatly facilitate boiler operation.

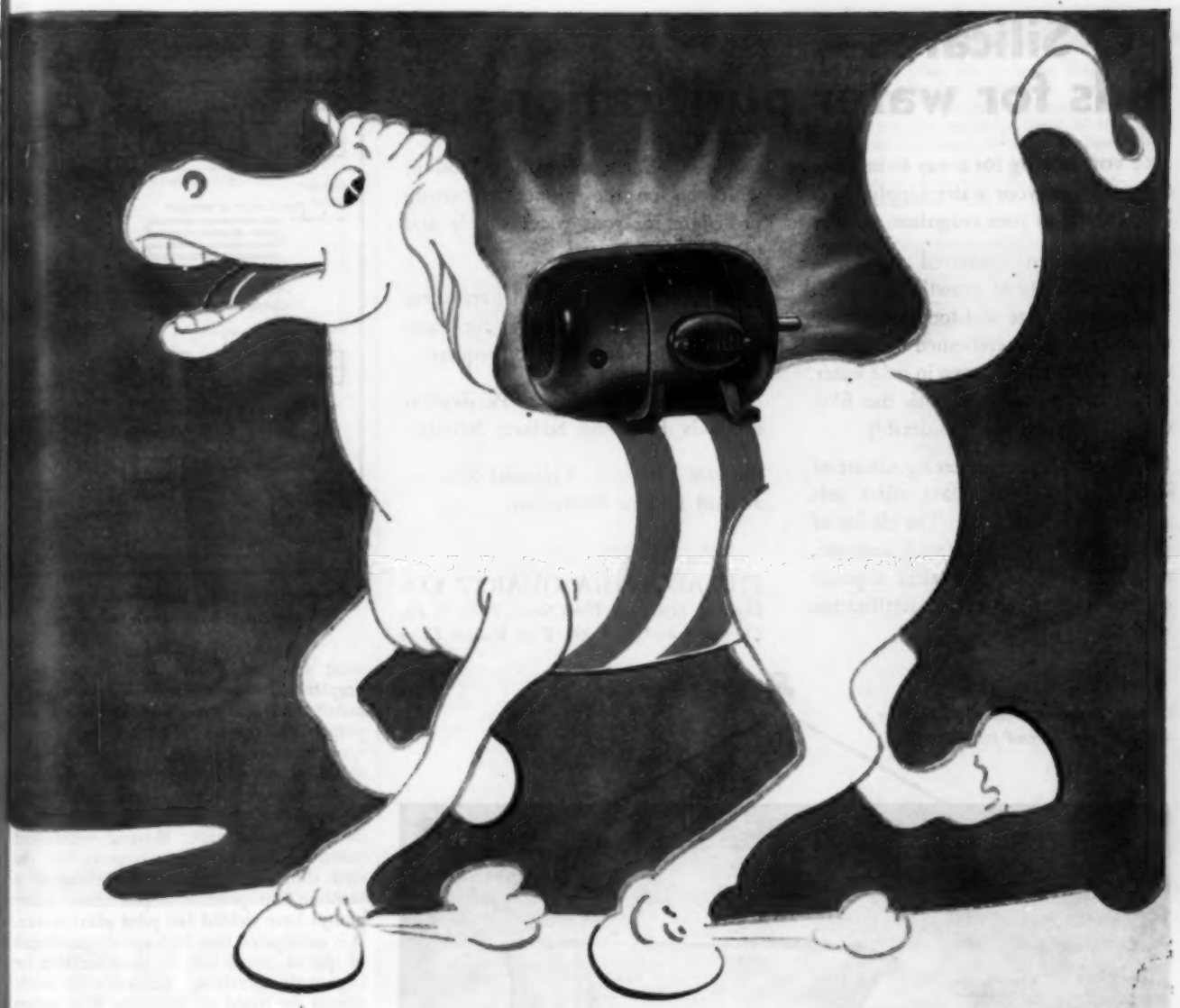
WOOD HYDROLYSIS

RAPHAEL KATZEN
Chemical Engineer
Cincinnati, Ohio

RECENT development of a continuous process for hydrolysis of wood, which yields lignocellulose residues for plastic applications, has indicated considerable promise with regard to replacement of batch processes which are themselves in early stages of commercialization. In this relatively new field of chemical engineering development, progress from batch to continuous operation is being condensed into a short period of time. As a result, more direct comparisons of technical efficiency, economy, and ease of control are possible upon equivalent bases.

Considerable pilot plant operation has shown that hydrolysis of wood to commercially useful lignocelluloses, by acid or buffered treatments, may be completed in 1 to 5 min. in the continuous process, as compared to 15 to 180 min. in batch processes. Perhaps most significant is the fact that when the continuous process is used the hydrolysis reaction, in the heterogeneous system "dilute sulphuric acid-wood," is subject to a high degree of control, therefore, conditions and results are readily duplicated. Batch processes, on the other hand, have not always yielded consistent results because material distribution, temperature, and catalyst or buffer content are non-uniform.

From the design standpoint, equip-

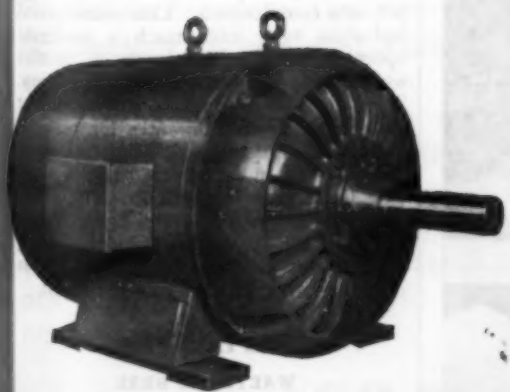


It may come to this—
but we won't cut Howell Quality

Yes, it may even come to the point where we have to press the good old Howell Horse into service to make deliveries on our famous motors. That's how serious the delivery situation is in the entire electric motor industry today.

But there's one thing you can count on now, as always—*we'll never, never cut Howell quality.* Every Howell Motor is built of the finest material, statically and dynamically balanced, and thoroughly insulated throughout.

So, until the delivery situation clears up, please bear with us. We recognize our obligations fully. We are putting forth our maximum efforts to build more and more Howell Motors, and to see that they are distributed among users whose needs are most vital to the war effort. This, we know, is as you would have it.



Howell Enclosed, Fan-Cooled Motor — Type K. Howell Totally Enclosed, Fan-Cooled Motor (shown above). Available through 125 Hp. . . . all working parts are protected against dust, fumes or moisture . . . Fan cooling prevents undue temperature rise (motor overheating) . . . All steel, streamlined housing provides minimum weight and greater compactness of overall length . . . built to N.E.M.A. frame dimensions . . . special horizontal and vertical fan-cooled motors are available.

Also a wide range of other types of motors up to 150 Hp.

HOWELL ELECTRIC MOTORS COMPANY

HOWELL, MICHIGAN

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ARE YOU looking for a way to improve the quality of your water supply? Try PQ Silicates as your coagulant aids.

Silicates, when converted into sols, increase the rate of growth of the floc as well as its size and toughness. Suspended solids are enmeshed in this floc which settles rapidly even in cold water. Thus water is clearer, with the filter capacity stepped up considerably.

Four methods for converting silicate of soda in useful coagulant silica sols are currently practiced. The choice of the reacting chemical (acid, ammonium salts, alum or iron salts) depends on the water and the sterilization method.

Our technicians are glad to consult with you on the proper converting procedure for your water supply and to arrange for a test.

Your reference file should have these publications on PQ Silicates for water purification. Available upon request.

Bulletin No. 52-4. Water Purification Methods Involving Sodium Silicates.

Bulletin No. 52-5. Colloidal Silica as an Aid to Floc Formation.

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Dept. A, 119 South Third Street, Phila. 6, Pa.
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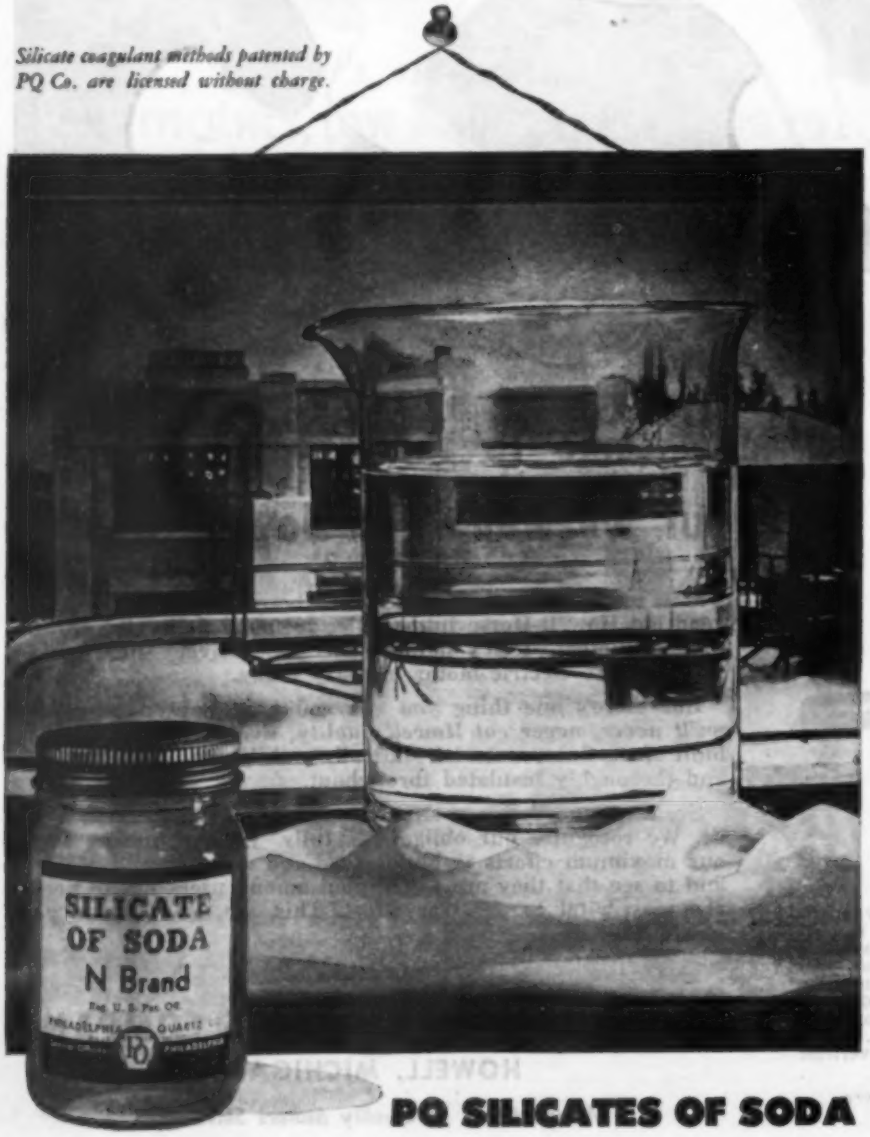
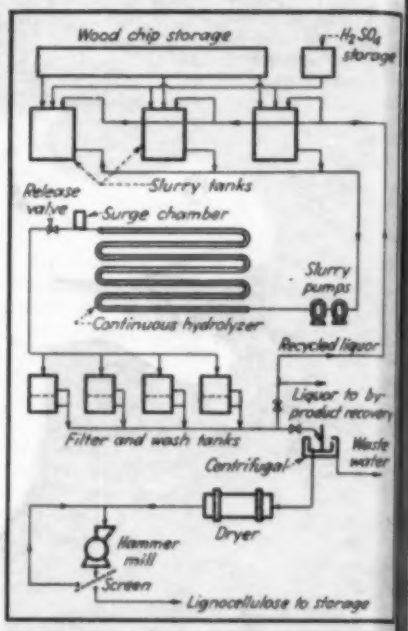
Silicate coagulant methods patented by PQ Co. are licensed without charge.



PQ SILICATES OF SODA



Production of lignocellulose by continuous hydrolysis of wood

ment for continuous wood hydrolysis is simpler and more economical to construct, install, and operate. The hydrolysis unit proper is assembled from extra heavy pipe size Herculoy, Everdur, Monel, or cupro-nickel tubing, with slightly modified unions or companion flanges. Heating is readily accomplished by direct and continuous steam injection under thermal instrument control. Pumping mechanisms for the feed slurry still present something of a problem but positive displacement rotary pumps have yielded fair pilot plant service. It is anticipated that high-speed centrifugals of special design will be more suitable for large scale operation. Release valve mechanisms are based on hydraulic flow factors determined for the hydrolyzed slurry. As in most continuous processes, design and operational problems are simplified with larger units.

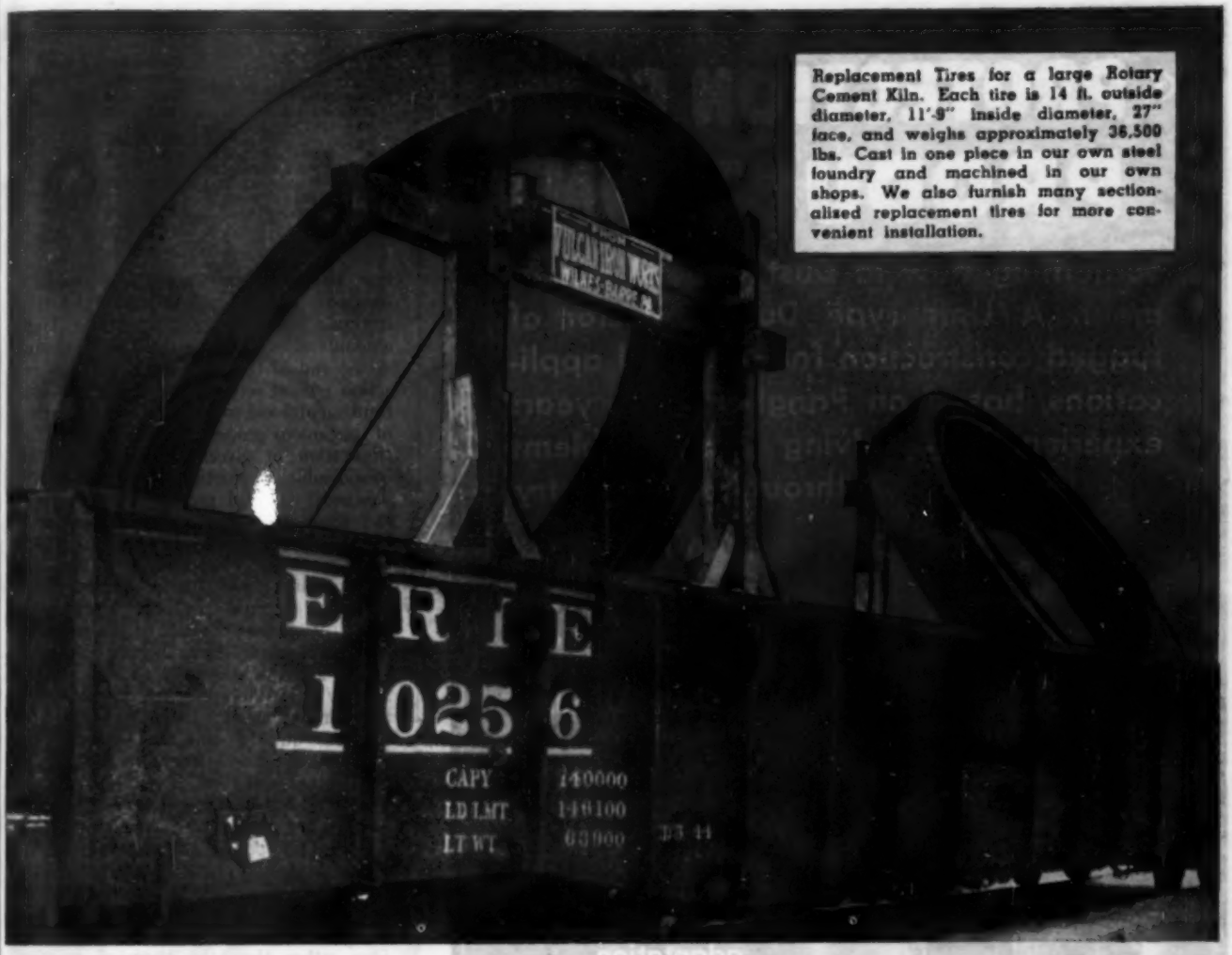
Flexibility of plant operation also enters into consideration. Continuous wood hydrolysis tube units reach a moderate optimum size; multiple units in parallel would be used for volume production. Thus, operations could be maintained at a high level with allowances for periodic inspection, cleaning, and maintenance.

Other steps in the process, namely: wood and feed slurry preparation, hydrolyzed slurry filtering and washing, lignocellulose drying, grinding, screening, and packaging are also readily adaptable to continuous operating with the modern equipment.

EXPLOSIVES

WALTER E. BERL
Carnegie Institute of Technology
Pittsburgh, Pa.

THE PROBLEM of batch versus continuous operation in the explosives industry is primarily concerned with improvements in safety of the operation. Modern practice accentuated by the stress of wartime demands for quick erection of plants and large output, has led to the adoption of batch nitration processes for the produc-



Replacement Tires for a large Rotary Cement Kiln. Each tire is 14 ft. outside diameter, 11'-9" inside diameter, 27" face, and weighs approximately 36,500 lbs. Cast in one piece in our own steel foundry and machined in our own shops. We also furnish many sectionalized replacement tires for more convenient installation.

DEPENDABLE SERVICE

on Large Cast-Steel Replacement Parts

Repeat orders are the best evidence of satisfactory service and Vulcan has been furnishing large cast-steel replacement parts to many well-known organizations for nearly a quarter of a century. The two tires shown above are not only a repeat order, but also illustrate another important point—that our replacement-part service is not confined to equipment of our own original manufacture.

Write us regarding any requirement involving either carbon or alloy steel castings up to approximately 40,000 lbs. in unit weight. We provide any desired degree of engineering, pattern-making and machine-shop service; including the manufacture of complete special machinery according to the purchaser's designs and specifications. Estimates furnished promptly on request.

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Main Office and Works **WILKES-BARRE, PA.,** New York Office 50 Church

Rotary Kilns, Coolers and Dryers	Toothed, Double-Roll Crushers	Heavy-Duty Electric Hoists	Steam Locomotives
Rotary Retorts, Calciners, Etc.	High-Speed Hammer-Type Pulverizers	Self-Contained Electric Hoists	Diesel and Gasoline Locomotives
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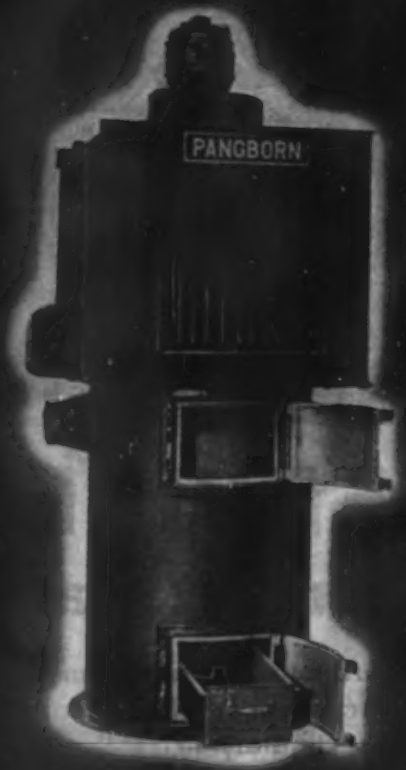
Automatic Quick-Lime Hydrators	Shaking-Chute and Chain Conveyors	Cast-Steel Sheaves and Gears	Electric Locomotives and Larrys

« PROTECTION FOR PRODUCTION »

Something new in Dust Control equipment. A Unit Type Dust Collector of rugged construction for industrial applications, based on Pangborn's 40 years experience in solving dust problems throughout industry.



A FEW OF THE MANY NEW FEATURES

- Self-contained. Occupies minimum floor space.
- Flexible in arrangement to permit adaptation to variety of field conditions.
- Easily accessible for inspection, servicing and adjustment.
- Minimum piping and installation expense.

Arrangement details, operating data and photographs are available in Bulletin No. 910. A copy will be sent to you upon request—no obligation, of course!

ARMY E NAVY

PANGBORN

WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT

PANGBORN CORPORATION · HAGERSTOWN, MD.

Comparison of Nitration Methods

	Continuous Nitration		Batch Nitration
Nitrator volume, gal	4.5	30	
Nitroglycerine content, lb.	24.5	103	3,535
Nitroglycerine production, lb. per day	5,520	31,000	
Time of contact, min.	0.4	4.7	
Radius of heavy damage in case of full explosion, yd.	18.2	37.5	220
Radius of lighter damage in case of full explosion, yd.	35.4	75	440

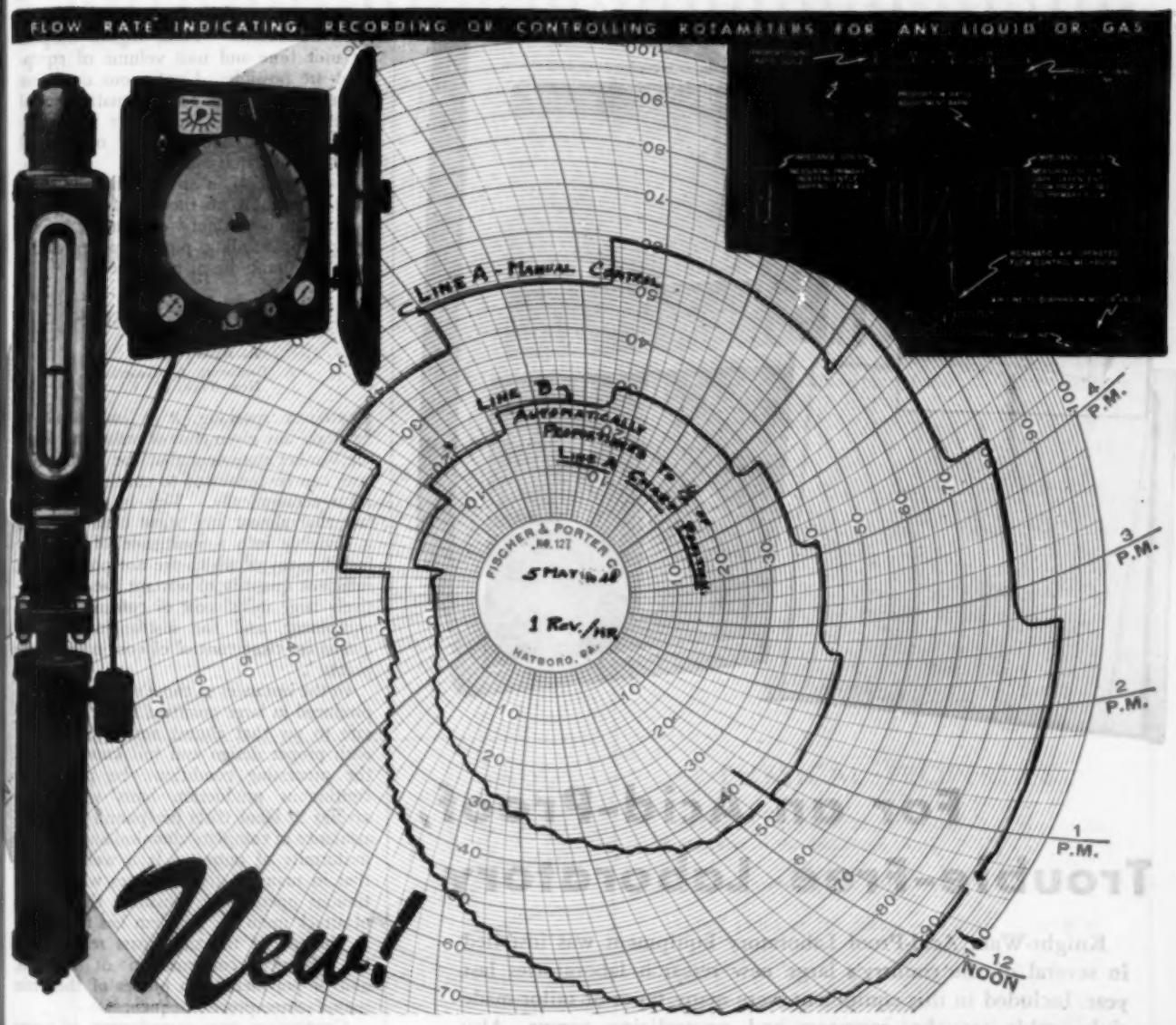
tion of the more common organic explosive compounds such as nitrotoluenes, glycerine trinitrate, and picric acid. The large amounts of explosible materials during and at the end of the exothermic nitration reaction present serious safety hazards. The fundamental and most important advantage of continuous processes, for example in the trinitration of glycerine, consists in the considerable reduction of potentially dangerous material present in any part of the apparatus. The accompanying table shows data comparing the continuous and batch nitration of glycerine.

Conversion from batch to continuous operation is only advisable however in those cases where the rate of the nitration reaction is rapid. Thus the first two nitro groups are readily introduced into toluene at only moderately elevated tempetatures, the trinitration of phenol and glycerine proceeds quickly, and that of pentaerythritol or hexamethylene tetramine, using 100 percent nitric acid, is very rapid. Cellulose nitration, on the other hand, is sufficiently rapid only when the mixed acid contains phosphoric acid instead of sulphuric acid or if the cellulose is properly pretreated. Here, the determining step is the diffusion rate of mixed acid into, and of spent acid out of the interior of the fiber rather than the chemical reaction rate. When two incompletely miscible liquid phases are present, maximum saturation of one phase with the other should be obtained. This can be accomplished by efficient stirring or by countercurrent flow in packed columns.

Slow reactions like the trinitration of dinitrotoluenes or the preparation of mercury fulminate or tetranitromethane are unsuitable for continuous production. The slow rate may be due either to an unfavorable electronic configuration in the aromatic nucleus or the existence of a number of time-consuming intermediate reaction steps. Such reactions would present serious problems in the design of reasonably compact plants.

Success of a continuous operation will depend on the possibility of easy phase separation (glycerine trinitrate from spent acid) or the occurrence of a topochemical reaction (cellulose in mixed acid, ammonium picrate in ammonia saturated nonsolvents). When the separation of the nitrated material from the spent acid is difficult (glycerine trinitrate in presence of impurities, hexogen in presence of formaldehyde and nitric acid), requiring a long settling out period, continuous production becomes difficult and dangerous.

The smaller quantities of material undergoing reaction in a continuous operation considerably simplifies the cooling and mixing problems, permitting nitration reactions to be carried out at higher temperatures than would be considered safe under



ROTAMETER FLOW RATIO CONTROLLER

automatically proportions two flows with high accuracy!

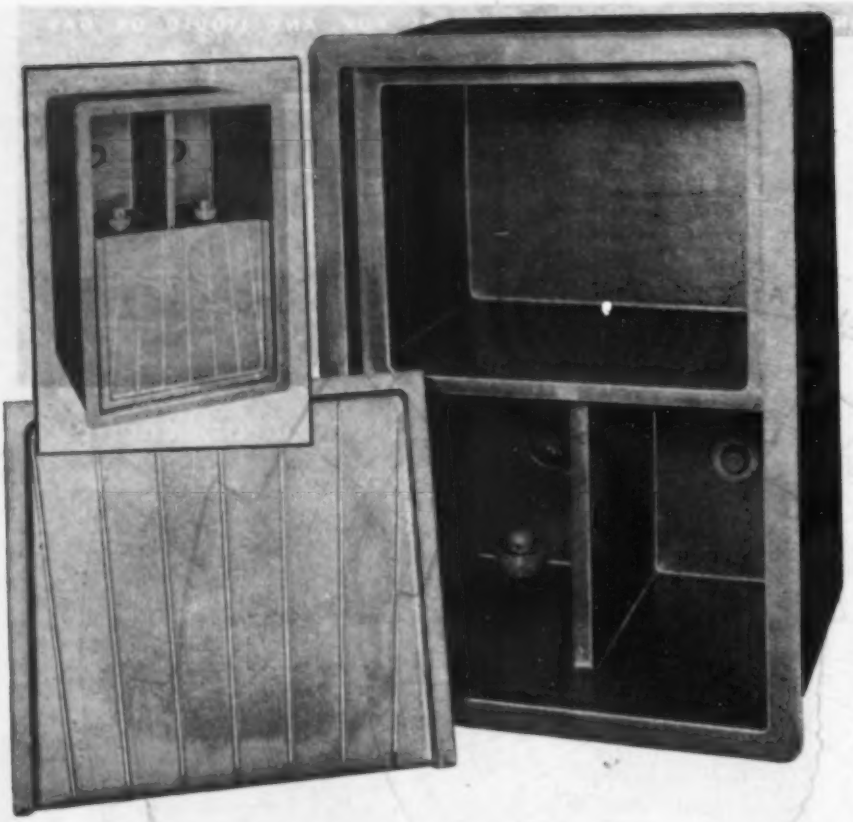
If you have a ratio flow control problem where you wish to keep one flow at a fixed percentage of a second *variable* flow, the new Rotamatic Ratio Flow Controller will do the job automatically for you. Furthermore the ratio may be varied at will by a turn of the flow ratio button. The device for doing this remarkable job of proportional control is so simple and so positive that what was once a difficult control problem has become easy and also reasonable in price.

In the flow chart shown above, the ratio index button has been set for proportioning at 1:2. Notice how accurately this proportion has been maintained, in spite of rapid flow fluctuations and variations over the full flow range of the rotameters.

The Ratio Controller operates as follows: Two rotameters with electric transmission for remote reading are placed in the respective flow streams. The remote flow-responsive balance beams from these two rotameters are placed back to back and connected by a cross beam, as shown in the above sketch. From this cross beam is suspended an arm whose position may be changed at will by sliding it on the beam. This suspension arm is connected to a Rotamatic air-operated control mechanism which in turn transmits air pressure to an air-operated valve in the flow line of the stream which is to be maintained at a fixed percentage of the main flow. It can be seen that the position of the arm suspended on the cross beam determines the control point or in other words, the flow ratio of one stream to the other. Liquid flows from 1GPM up to 6,000 GPM may be proportioned, and gas flows in equivalent volumes.

The full and interesting details in regard to the new Rotamatic Ratio Controller are told in our bulletin 50-A which we will send to you without any obligation. Owing to the paper shortage, please make your request upon your Company letterhead. Write to FISCHER & PORTER COMPANY, 1805 County Line Road, Hatboro, Pa.

FISCHER & PORTER COMPANY



For an Acid-Proof, Trouble-Free Laboratory

Knight-Ware Acid-Proof Laboratory Equipment was installed in several of the country's large new research laboratories last year. Included in this equipment were many types of tailor-made sinks, table troughs, receptors and neutralizing sumps. Also Knight-Ware acid-proof pipe and fittings were largely used for the drain lines and acid fume ducts. Taken together this Knight equipment is providing a maintenance-free laboratory.

The photo above shows a special Knight laboratory sink with removable drain board and cover. Except for the cover, the entire sink and outlet is made of one solid, corrosion-proof piece.

Acid-Proof Trap

The Knight-Ware Laboratory Equipment catalog illustrates and describes many of these pieces. Write for a copy.

MAURICE A. KNIGHT
105 Kelly Avenue, Akron 9, Ohio

KNIGHT-WARE
CHEMICAL EQUIPMENT

batch conditions. Thus, higher outputs per unit time and unit volume of equipment are possible. Continuous operation is particularly suited for automatic control of temperature and flow rates with consequent elimination of the operational variations of batch operations.

The reduction in size of the apparatus reflects favorably on the initial investment in corrosion-resistant equipment, fixed charges for building, piping upkeep and a more economic use of personnel.

SYNTHETIC RESINS

A. BROTHMAN
A. Brothman & Associates
New York, N. Y.

BROADLY speaking, it is impossible to take any given class of resins and make the blanket statement that the batch processes can be converted to continuous operation economically. This is due to the fact that almost any broad class of resins is divisible into a multitude of specialty forms, many of which are not produced in sufficient quantity to warrant the comparatively large initial cost of continuous type equipment, and the instrumentation required for close control of continuous type plants.

In the instances of those resins which are produced in large quantity, it is completely safe to say that almost any of these can, with proper design and full knowledge of the processing conditions, be put on a continuous production basis with large savings in labor costs per pound and with assurance of complete chemical and physical uniformity of output. It is well to note that in many of the instances where continuous operation is possible, the avenue of attack upon the problem lies frequently in the use of the single-pass reactors for the chemical condensation or reaction, and/or polymerization phases of the resin manufacture process sequences.

Continuous type manufacture of resins has been successfully employed in polystyrene resins, some types of urea formaldehyde resins, and most notably in the manufacture of GR-S and GR-N rubbers.

PULP DIGESTION

ROBERT T. SHEEN
Consulting Chemical Engineer
W. H. & L. D. Betz and Milton Roy Pumps
Philadelphia, Pa.

MANUFACTURE of paper and board in a continuous sheet on a paper machine has become an accomplished fact only within the last century. Batch digestion of the raw stock, however, is still the common and accepted practice in the industry but recent developments predict a future for continuous processing since continuous digestion has proved itself in a number of instances.

A continuous digester built by Paper and Industrial Appliances, Inc., produces high yields in the manufacture of certain semi-chemical pulps utilizing as raw material coniferous and deciduous woods, including waste from saw mills and veneer mills; also such raw materials as straw, bagasse and similar cellulosic materials.

Wood chips or other raw material are fed

ALLYL CHLORIDE

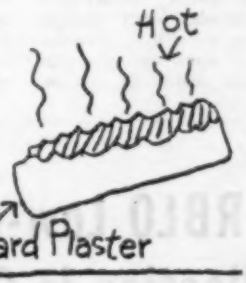
$CH_2 = CH - CH_2 - Cl$

Molecular Weight 76.50

This chemical intermediate is now available in commercial quantities. Under suitable conditions both its chlorine atom and double-bond react readily. In general, it's reactions are rapid . . . show unusual freedom from by-products.

IN SEDATIVES AND ANESTHETICS Allyl Chloride's contribution is a less toxic effect, reduced nausea and rapid action with minimal disturbance to metabolism.

SYNTHETIC MUSTARD OIL is another end use, and here Allyl Chloride provides advantages of low cost.



ALLYL STARCH EXPERIMENTS have shown that low-cost "air-drying" or heat-setting coatings can be made which have hard, but flexible surfaces resistant to heat, chemicals, and weathering.

The polymerizability of many of its derivatives makes Allyl Chloride valuable as a raw material in the manufacture of plastics and synthetic resins.

Your inquiries about this or other Shell Chemical products are invited

SPECIFICATIONS

Purity . . .	Minimum 97% allyl chloride by weight (Impurities are largely beta chloropropylene)
Specific Gravity 20°/20° C.	0.937 to 0.940
Color	Colorless to straw
Distillation Range . . . . (A.S.T.M. D268/33) . .	Below 43° C. None Above 49° C. None
Acidity	Maximum 0.01% calculated as hydrogen chloride
Weight	7.81 lbs. per gallon at 20° C. (approx.)

PHYSICAL PROPERTIES

Several of the physical properties of allyl chloride are given in the following table:

Specific Gravity at 20°/4° C.	0.9374
Boiling Point at 760 mm.	44.9° C.
Melting Point	−134.5° C.
Flash Point, Tag Open Cup	−20° F.
Tag Closed Cup	−25° F.
Vapor Pressure at 0° C.	119 mm. Hg.
10° C.	191 " "
20° C.	296 " "
30° C.	441 " "
Specific Heat	0.315 (0° C.)
Refractive Index, N_D^{20}	1.4151
Coefficient of Expansion . . .	0.000783 per °F.
Heat of Combustion . .	5,940 gm. cal. per gm.

Azeotropic Data: Allyl chloride forms a constant boiling mixture with water at 43.0° C., containing 97.8% by weight of compound.

For further properties and uses communicate with either of the addresses below.

SHELL CHEMICAL Division of SHELL UNION OIL CORPORATION
100 BUSH ST., SAN FRANCISCO 6, CALIFORNIA
R. W. GREEFF & CO. Eastern Sales Agent 10 ROCKEFELLER PLAZA, NEW YORK 20. TRIBUNE TOWER, CHICAGO 11

√ Compressors
√ Engines
√ Pumps
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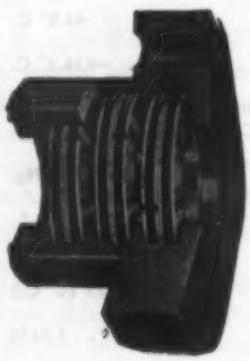
Type No. 270. Designed especially for gas compressors. France Metal "Full-Floating" Packing is outstanding for its long wearing qualities. Eliminates frequent shut-downs.



Type No. 190. Designed for shallow stuffing boxes requiring ⅝" packing or larger — pressures to 150 pounds.

Specify the packing that L-A-S-T-S—FRANCE "Full-Floating" Metal Packing. Ask for Folder No. M-4.

THE FRANCE PACKING COMPANY

Tacony, Philadelphia, Penna.

Branch Offices in Principal Cities

Original FRANCE METAL PACKING

Continuous digesters built by Paper and Industrial Appliances, Inc.

from a storage bin to a specially designed screw feed unit to introduce the material to the pressure chamber. The raw materials are compressed by this feed, forming a plug that acts as a seal and at the same time expels excess air and moisture. Operating pressures of 125 to 170 lb. per sq. in. are employed. The raw material first passes to the cooking zone where chemicals are added by high pressure controlled volume chemical pumps. Steam is also added at this point, and the raw material readily absorbs the steam and chemicals while passing through this cooking zone. The reaction chamber consists of a number of reaction chamber units through which the chips or raw material is conveyed and uniformly mixed by screw conveyors permitting a uniform and continuous cooking operation. At the end of the travel through this system, the cooked pulp while still under steam pressure is moved through a disk refiner where mechanical defibrating action takes place before the pulp is discharged through the discharge valve. The discharge valves release the pulp at approximately 30 to 50 percent consistency after the combined thermal, chemical and mechanical treatment, and this pulp is then diluted in the mixing chamber to the desired consistency on its way to the chest.

This continuous digester is flexible in design to handle various types of raw materials and to give the quality of pulp desired. This digester has been manufactured in one, two, and three reaction chamber units. The single unit will normally give a cooking time of 4 to 6 min. while the triple unit will give a

NORBLO Low-Cost Dust Collection is Continuous Without Shut-Downs

★ Automatic bag type dust collection equipment developed by Norblo, is especially adapted to large scale continuous production, which in smelting and chemical industries has largely superseded batch methods.

Many Norblo "bag houses" with cyclic bag cleaning are operating continuously, 24 hours a day for months, without shut-downs — and filtering capacity and efficiency are maintained at maximum.

★ Low cost fume and dust collection calls for Norblo advanced design which protects your investment against obsolescence, and for continued low maintenance. You save all four ways with Norblo engineered equipment and you get guaranteed performance. Write for descriptive folders.

Norblo

THE NORTHERN BLOWER COMPANY

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Reactions often go awry if there's moisture in materials being processed. That's why plant designers provide dryers, working on-stream, charged with Activated Aluminas—to help make certain that reactions stay on the straight and narrow path.

Alorco Activated Aluminas dry air, gases and many organic liquids to dewpoints below −110° F. One charge usually lasts for years. Standard machines are available which reactivate the drying agents as they become laden with moisture, assuring an uninterrupted flow of dry materials.

We'll gladly advise you on the proper Alorco Activated Aluminas for your purpose and refer you to builders of drying machines.

ALUMINUM ORE COMPANY, Subsidiary of ALUMINUM COMPANY OF AMERICA, 1910 Gulf Building, Pittsburgh 19, Pennsylvania.

ALUMINUM ORE COMPANY

ALORCO

Aluminas and Fluorides

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NEW 6" I.D.

REX-FLEX S.S. FLEXIBLE METAL TUBING!

• To meet new industrial requirements in many fields, REX-FLEX Stainless Steel Flexible Metal Tubing is now being produced in a new 6" I.D. size! This latest addition to the C.M.H. line of flexible metal hose makes possible the use of REX-FLEX in numerous new applications. Sizes now range from 5/16" to 6" I.D. (Incl.). Five standard wall formations are available.

In addition, this new 6" flexible metal tubing has all these outstanding REX-FLEX features: *18-8 Austenitic Stainless Steel . . . Non-Corrosive . . . Withstands Extremes of Temperature . . . Light Weight in Comparison to Strength . . . Great Burst and Crush Strength . . . High Fatigue Resistance . . . High Vibration Qualities . . . Pressure Tight for Liquids and Gases . . . Manually Bendable in Multiple Planes . . . Fittings Seam Welded to Form Uni-Metal Assemblies.*

Learn how REX-FLEX Stainless Steel Flexible Metal Tubing can meet your requirements. Write today for complete information!

Flexible Metal Hose for Every Industrial Use

ARMY E NAVY

CMH CHICAGO METAL HOSE CORPORATION

MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

cooking time of 20 to 22 min. The higher the percentage of chemical used, the longer is the cooking time required to utilize fully the action of the chemicals. It is at once evident however that this represents a material decrease in normal digestion time. Flexibility of control is most important for continuous pulp digestion due to the variables encountered.

With this unit the rate of feed of raw material is controlled by the speed of the raw feed screw. Steam pressure can be varied and controlled. Cooking time can be varied and controlled. The quantity of chemical fed is controlled by the accurate action of the controlled volume pump. The system is essentially a vapor system and not a submerged system, so that the chemical action is completed in a shorter period of time than would be possible with a submerged system, resulting in considerable economy in steam requirements. The volume of waste liquors can be reduced—an important factor in stream pollution problems.

This continuous system is a typical example of what lies ahead in continuous processing in the change from batch methods, and is also an excellent example of the improvements that are possible in control and flexibility, assuring a greater uniformity of product.

DRY COLORS

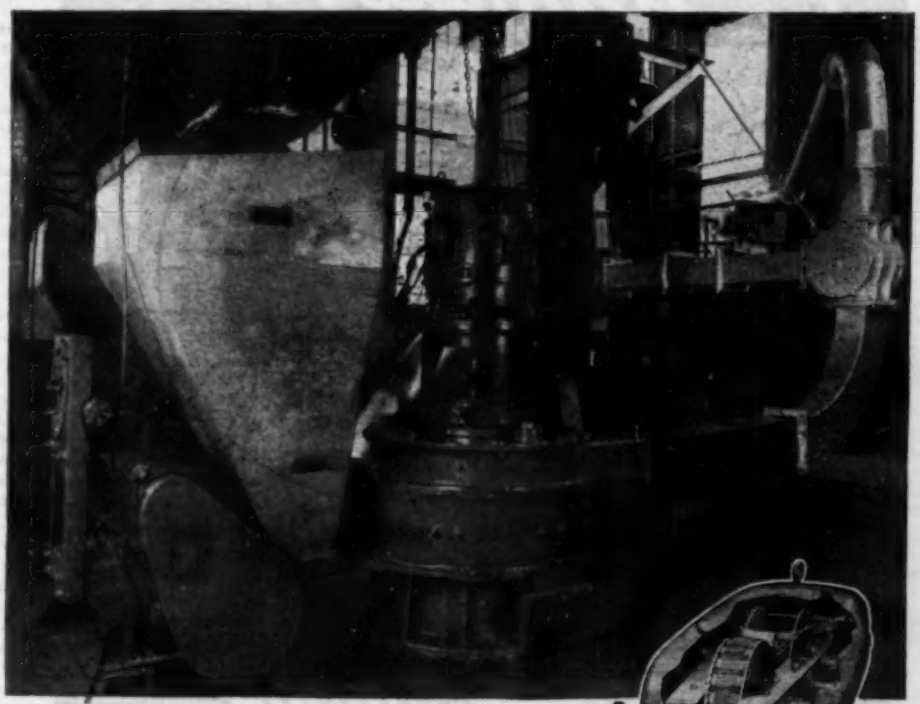
H. B. KIRKPATRICK

Prod. Mgr., Chemical Color Div.
Reichhold Chemicals, Inc., Brooklyn, N. Y.

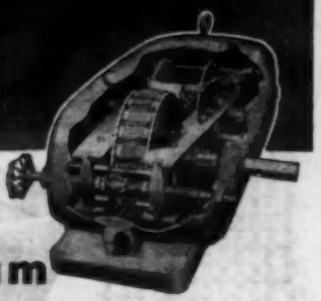
Dry color manufacture has been considered a single industry on the assumption that technical production problems are the same for all types of dry colors. This is not the case. The important types differ sharply in chemical structure, and in chemical and physical properties. They require an equally differentiated plant for production in accordance with maximum functional demands.

The industry has been restricted in its growth and limited in its technological development by the economic factors which control all relatively small competitive industries. During peacetime years, the color industry produces a highly diversified line of pigments ranging in price from a few cents to several dollars per pound, each inherently different from the rest in the production problem it presents. According to the Bureau of Census' report for 1939, this country produced in the most important pigment categories (C. P.—chrome yellows and oranges, iron blues, chrome greens, paras, lithols, and toluidines.) approximately 62,000,000 lb. aggregate, with a total value slightly in excess of $15,000,000. It is obvious that a competitive industry of this size, producing a number of products of widely separate characteristics, cannot support the large investment and tremendous productive potential of a fully functional or rational plant design. It will not be possible to make use of plant equipment now available unless there are very great increases in the use of dry colors and a corresponding sharp reduction in the number of individual pigment types. The effect of this interrelated change has been demonstrated to a limited extent during the war years when the main productive effort has been concentrated on three or four essential items and manufacturers have made use of new equipment and streamlined methods of production. In terms of actual need and neglecting

Says the Engineer:
"We Sure SPLIT HAIRS with this one!"



Right: Boiler room in the plant of the Whiting Corporation, showing two of three pulverizer units feeding powdered coal to boilers. Link-Belt P.I.V. gear speed variators enable the engineer to adjust the feed to meet fluctuating demands for steam. Regulation is instantaneous and precise to a minute-fraction of a revolution per minute. Efficiency and economy of the plant is "immensely improved" since installation, states the engineer.



Sensitive Combustion Control to Meet Varying Demand for Steam Achieved with Link-Belt P.I.V. Gear!

Close-up view of drive regulator on Whiting Pulverizer. Motor removed, showing Link-Belt P.I.V. gear, set in position. Separate control wheel, connected to P.I.V. by roller chain, is also geared to large indicator dial.

To regulate the feed of powdered coal to boilers, in exact relation to load demands, pulverizers built by Whiting Corporation rely on Link-Belt P.I.V. speed variators. With this all-metal, positive and efficient device, the feed can be set instantly at any point, over a wide range.

Designers, builders and users of industrial machinery find P.I.V. gear units save power, time and material by giving quick, accurate timing of machines and processes. Data book 1874 gives full details and engineering data. Write for a copy, today!

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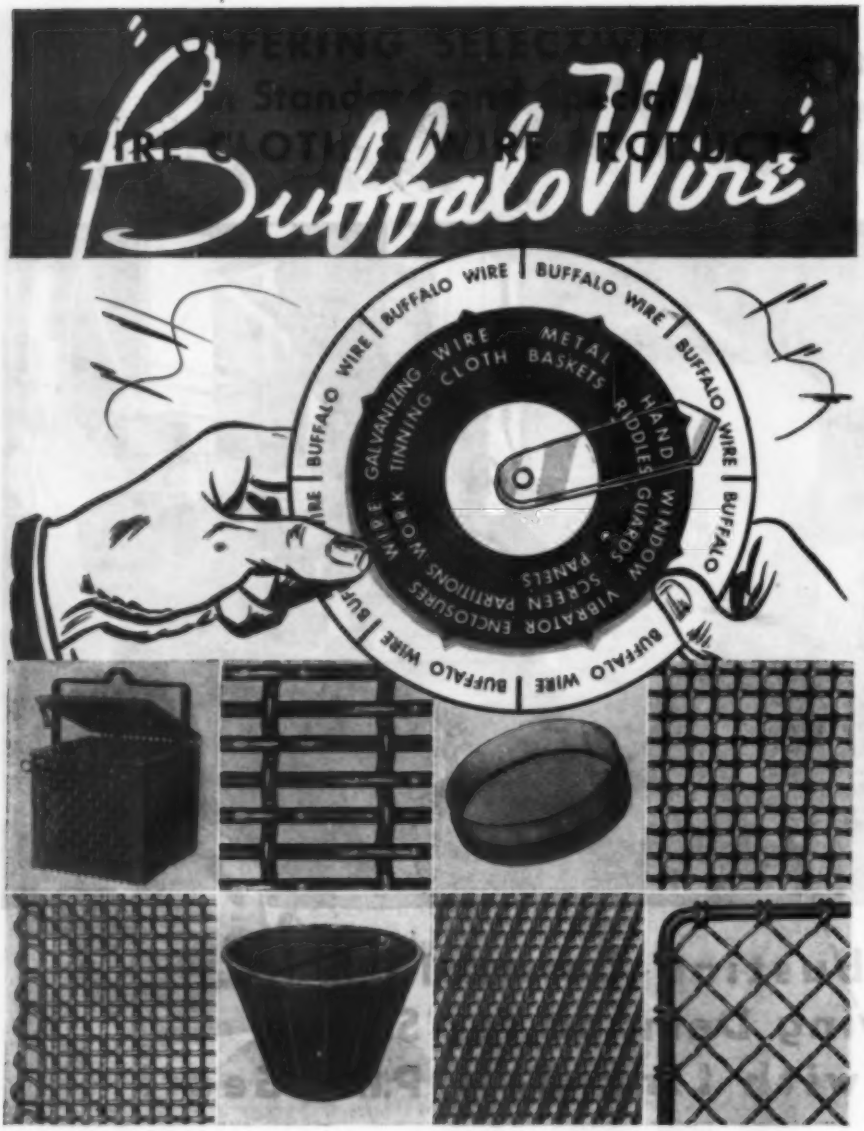
POSITIVE INFINITELY VARIABLE SPEED CONTROL



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More than likely you'll reach the same conclusion as thousands of other plant operating men, purchasing agents and engineers the nation over: . . . that in dealing with "Buffalo Wire" you have *selectivity*—the opportunity of choosing from an unusually large and diversified line the products that *best fit your* own applications and operating conditions.

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MANUFACTURER OF ALL TYPES OF WIRE CLOTH FOR OVER 76 YEARS

Buffalo WIRE WORKS CO., INC.

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the vagaries of our economy, there is no reason why colors cannot be used in the postwar period in very much larger quantities, if in less variety, than at any time in the past. If these conditions are fulfilled, a number of fundamental changes in production methods can be effected.

At present, the great bulk of dry color production is based on the unit processes of open wooden tank precipitation and washing, filter pressing, truck drying, and hammermill grinding. This standardized process represents the lowest common multiple of all the quantitive factors, both technical and economic, which determine the level of development in the dry color industry. On the basis of present knowledge, this standardized process can be replaced by continuous precipitation in a small reaction chamber which discharges continuously through an overflow pipe to the washing unit. In this initial stage of precipitation, modifications must be introduced for each of the different products to be processed. These will depend on the rate of the fundamental reactions and the use in some cases of chemical as well as mechanical methods of catalyzing or accelerating these reactions, the number of subsequent secondary unit processes, such as oxidation, reduction, heating, and coprecipitation of other salts. To meet these various requirements, it may be necessary to introduce special dispersion equipment, continuous heat exchangers or a series of reaction chambers.

Washing may be effected in a number of ways. If the material is of a relatively high specific gravity, a centrifuge may be used. For materials whose specific gravity approximates 1.0 some alternative method such as continuous thickening and redispersion may be substituted. In some instances, the necessity for washing may be eliminated completely by making use of double decomposition reactions which form water as the secondary product. From this point, the pigment slurry may be dried continuously in a belt dryer or flash dryer. It may or may not be necessary to introduce a filtration unit into the process before drying and, in the case of flash drying particularly, the necessity for grinding after drying may be eliminated.

It is obvious that special high priced products which are used in relatively small quantities, such as Rhodamine Toners, will continue to be made by the classical methods now generally in use. The possibilities outlined are based solely upon technical speculations and do not take into account the many uncertain economic factors which will determine the future of this industry. War necessity has brought full use of all industrial resources for production and there is no rational barrier to their full use in creating an economy of plenty for the peacetime needs of the world in the years to come.

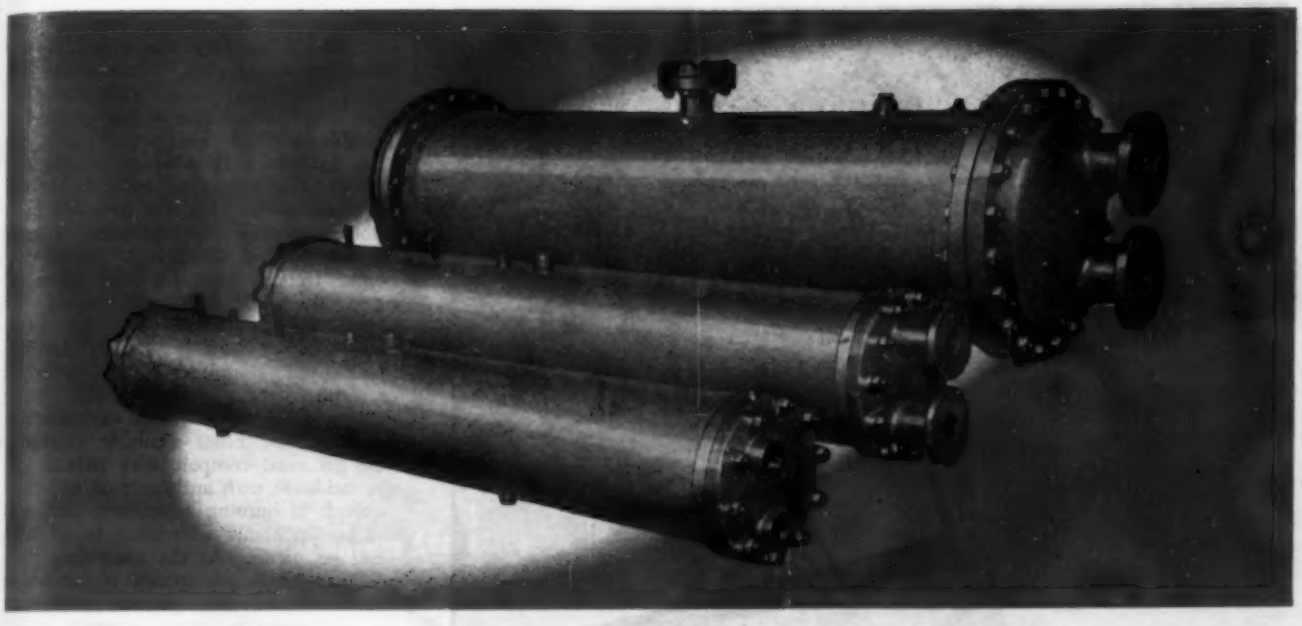
COAL AND OIL SHALE

JOHN M. WEISS
John M. Weiss & Co.
New York, N. Y.

IT IS extremely doubtful that the carbonization of coal will become a continuous process so long as the chief use of coke is in the blast furnace for steel production.

The blast furnace requires a dense strong, low volatile coke, which so far has been only produced economically in the batch byproduct or bee-hive coke ovens. The essential characteristic of a continuous process—motion—is antagonistic to a dense and strong residual product.

From the standpoint of a smokeless



SYMBOL OF QUALITY

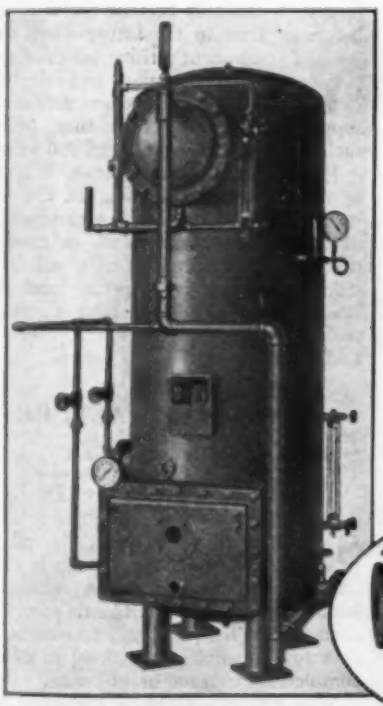
The insignia "B & G" on Heat Transfer Equipment is recognized everywhere as a symbol of genuine quality. It is assurance of skilled design, painstaking workmanship and time-tested performance.

The Freon Refrigeration Condensers illustrated above are typical of the workmanship and meticulous attention to detail which characterize all B & G Heat Transfer Equipment.

All three units have steel shells but vary in the materials used for heads and tubes. The larger unit has a brass head with tube sheet and tubes of copper-nickel. In the smaller unit, the heads are cast iron, coated inside with ⅛" copper. The tube sheets are copper-nickel, brazed to the steel shell, and tubes are of aluminum brass.

Beginning with a design most suitable for the job to be done, all B & G Heat Transfer units must measure up to four basic standards. They must transfer heat with top efficiency . . . they must be built of the proper materials . . . their construction must be proof against leakage and contamination . . . and finally, they must be easy to service if ever necessary.

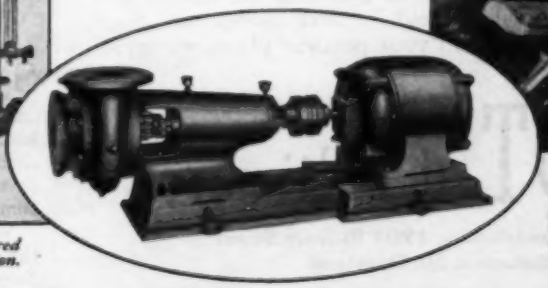
Whatever your requirements, B & G can satisfy them with either standard equipment or units built to your specifications.



An Evaporator-Distiller manufactured by B & G for the Maritime Commission.

B & G CENTRIFUGAL PUMPS

A complete line of pumps with semi-open or enclosed impellers. Furnished flexible-coupled or with motor and pump combined as an integral unit.



AT YOUR SERVICE

The large staff of B & G engineers and designers is always available to help you with any heat exchange problem you may have. Your inquiry is welcome.

B&G HEAT TRANSFER EQUIPMENT

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Where can the
BRANDT Fabricating Facilities
Fit Your Postwar Production?

Your postwar production will probably include some fabrication to be done by a reliable, experienced metal-working organization. That's where Brandt of Baltimore can fill a definite need!

For over fifty years Brandt has fabricated metals for scores of industrial uses. Present products range from small formed units of only a few ounces to huge fabricated assemblies weighing up to 30 tons.

The Brandt 8½-acre plant houses complete, modern equipment for shearing, rolling, forming and welding. Machine capacities range from the lightest gauge sheet up to and including 1¼" mild steel or ¾" armor plate. All metals, ferrous, non-ferrous and alloy, can be completely fabricated to your specifications.

And if you've hit a snag on your postwar product, our designers and engineers will welcome the opportunity to assist in planning the details and specifications. Naturally all plans will be held in strict confidence. So if there are fabrication or design problems in your postwar plans, we invite you to discuss them with

BRANDT of Baltimore

Charles T. Brandt, Inc., 1704 Ridgely Street
Baltimore 30, Maryland

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domestic fuel of moderate volatile content, which has been the object of the many low temperature carbonization processes, the situation is quite different. Here a continuous process may produce a desirable product and several processes have done so with adequate mechanical success. The economics however, except in certain special situations, have not been favorable to any wide extension of such processes. Basic changes in certain economic factors, especially the value of smokeless solid fuels and liquid tar byproducts, could change this situation and encourage wide development and installation of processes of this type. Broadly, the value of the chief products of coal carbonization is limited by other available materials. The gas must compete with natural gas, the residuum with anthracite or improved methods of burning bituminous coal, and the tar essentially with other liquid fuels from petroleum. As the competing fuels rise in value in any specific region where coal is available, the economic justification for continuous processes increases.

With oil shale treatment, the form value of the residue is not a factor. The distillate oil is the product of chief value and the only excuse for the venture. The scale of economic operation is such that only continuous processes merit consideration. With crude oil at its present level, it is certain that the treatment of oil shale will not develop into a large industry. Any operations at all, under present conditions, can only be justified for the purpose of obtaining information, which information can only become useful at some indefinite time in the future when shortage and consequently rising prices of crude petroleum make mining and treatment economical. As a defense measure to supplement petroleum in time of war, such information would be of real value.

For the near future at least, it appears as if continuous processing in the treatment of oil shale or in the carbonization of coal is not likely to fill an economic need and that developments will be restricted to some very special local situations or to large scale pilot operations, probably publicly supported, for fact finding purposes.

SOAP MANUFACTURE

ROBERT T. SHEEN
Consulting Chemical Engineer
W. H. & L. D. Betz and Milton Roy Pumps
Philadelphia, Pa.

SAPONIFICATION of vegetable oils by caustic soda resulting in soap is an old art, yet the basic common method of manufacture by the batch kettle process has changed but little and still requires several days for the multiple washing to effect a complete separation of glycerine.

Soap may now be made continuously by the Clayton process (M. Mattikow, *Oil & Soap*, August 1940. pp. 184-8) which is a method of handling organic materials at high temperatures and results in complete saponification with accompanying rapid separation of usable glycerine.

Oil and caustic solutions are placed in their respective feed tanks and preheated to a temperature of approximately 180 deg. F. The

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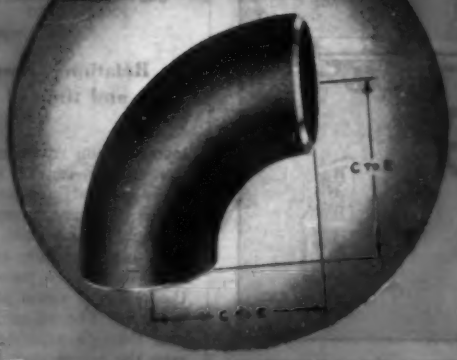

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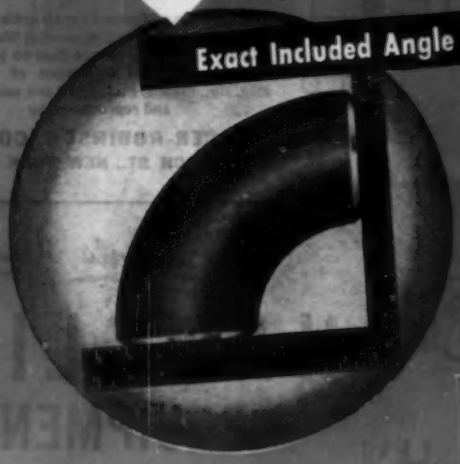
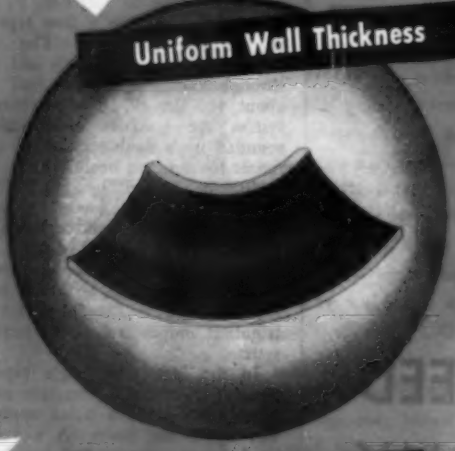
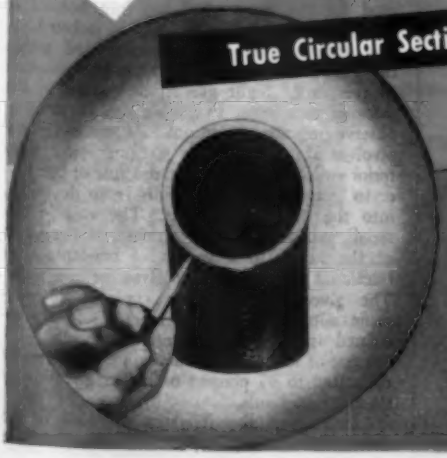


Uniform Wall Thickness



True Circular Section



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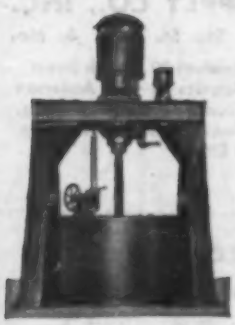

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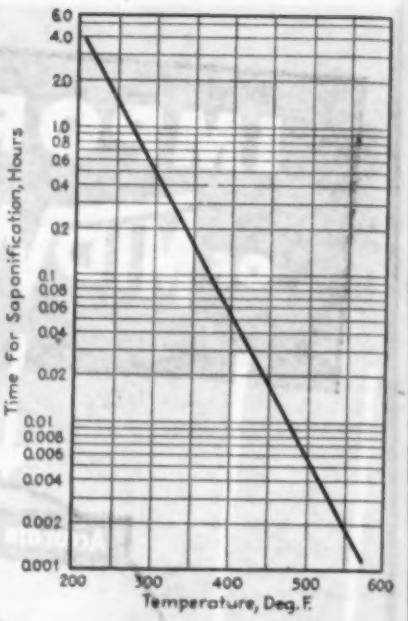
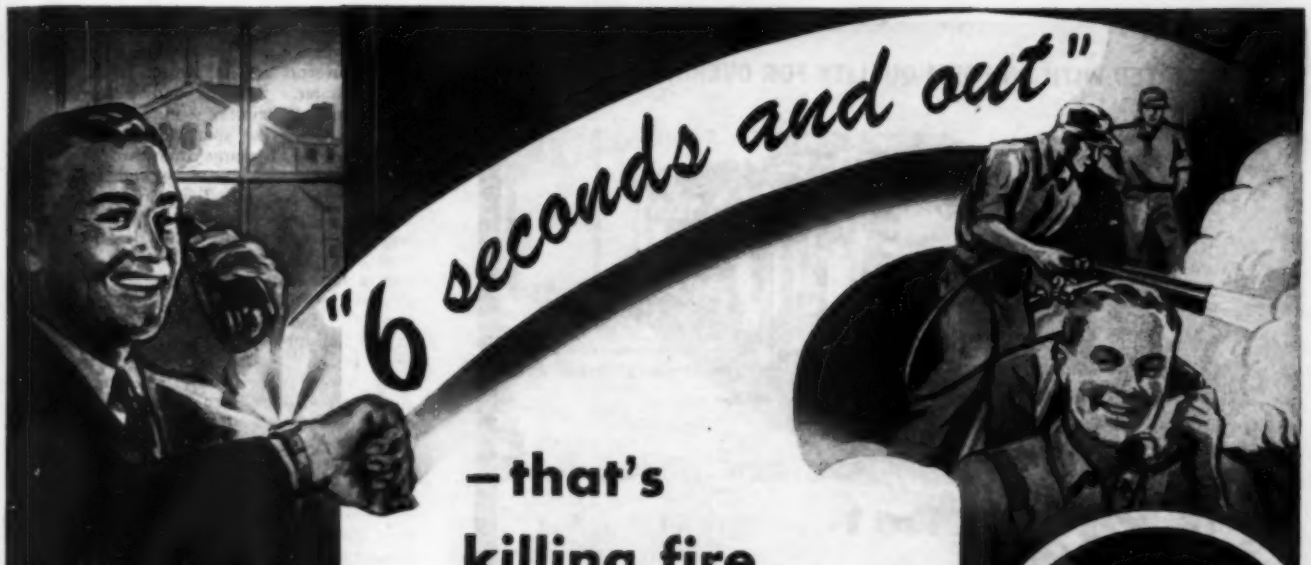


Relation between temperature and time of saponification

saponification number of the oil and the strength of caustic soda solution (normally, 25-50 percent) are accurately determined, after which they are pumped in the correct ratio, through heating coils, to the reaction chamber by a high pressure, controlled volume, metering Milton Roy pump. Each valve body on the pump is steam jacketed to help heat the material. The oil and caustic from the pump pass through separate nickel heating coils to raise the temperature of the oil to 275 deg. F. and the caustic to 180 deg. F. The oil and caustic are mixed in a flow type mixing unit in the soap generator. The mixture then passes to the reaction coils and in its passage through the first reaction coil is heated to about 410 deg. F. The reaction coils in the system are a series of pancake coils surrounded by a double jacket of insulating materials to conserve heat and are located above a furnace heated by gas. The saponified mixture enters the second reaction coil at about 420 deg. F. and emerges at 550 deg. F. and is then piped directly to the soap spray tower. Other designs permit a single reaction coil with a liquid heat exchange medium such as Dowtherm for uniform distribution and control of the heat input to the system.

In the tower the single pipe branches to direct the streams of reaction mixture on the chamber walls at a point approximately half way up in the tower. A nickel clad steel is used for the inner shell top and bottom of this tower and the side wall is jacketed. A heat transfer mineral oil is circulated within the jacket to maintain the desired temperature in this unit. Sight glasses are placed in the sides of the tower to enable the operator to observe interior conditions. A sweep agitator revolves at approximately 4 r.p.m. on the interior sweeping the bottom and side of the tower to insure transfer of all the soap deposited, into the conveyor troughs. The volatile materials pass off through openings in the dome of the kettle to a system of condensers for fractional condensation of glycerine and water. The glycerine condensate contains no inorganic salts and the small amount of soap entrained is negligible, being approximately 0.1 percent or less. The condensate may be rapidly converted to 95 percent or higher glycerine by standard methods.

Liquid soap discharged on the walls of the tower flows as a thin film and collects on the



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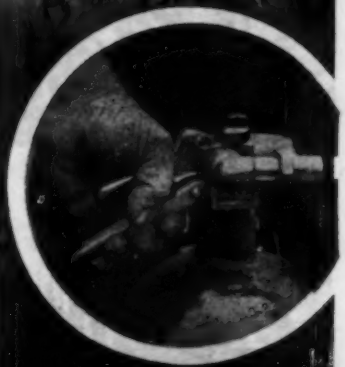

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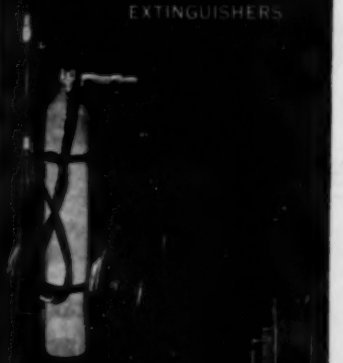

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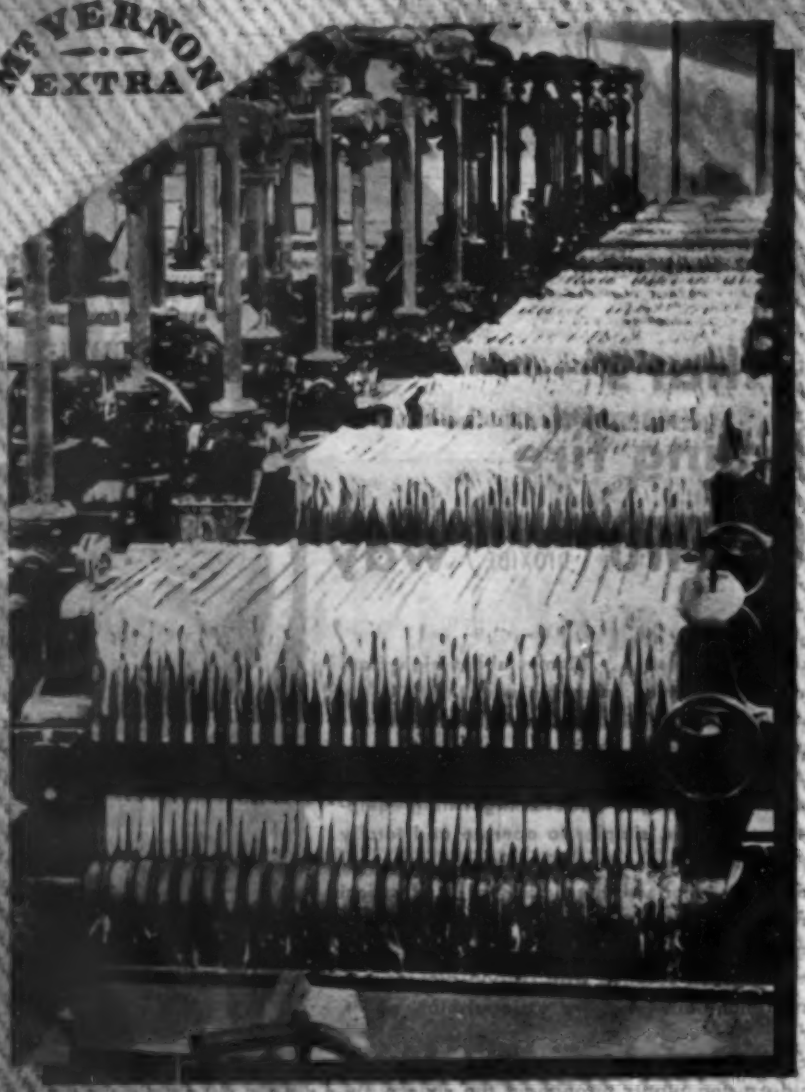

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bottom and is swept into the conveyor troughs. The troughs are jacketed and the shafts of the spiral conveyors are hollow for circulation of cooling water. Troughs and conveyors are constructed of stainless steel. The conveyor extends beyond the spray tower and a 4-in. unit takes the discharge from two 6-in. conveyors, compacting the soap and forming a seal between the spray tower and the outside atmosphere. The temperature of the soap has dropped to approximately 200 deg. F. by the time it is first exposed to the air, and is in such a form that it may be caked, flaked, or chipped by conventional methods when discharged. If it is to be caked, it is necessary to add moisture to the soap in the final conveyor because the soap discharged from the spray tower is practically anhydrous. The glycerine remaining in the soap varies from 0.5 to 1.0 percent depending on the nature of the raw materials used.

Proper control of temperatures throughout this process (both of the raw materials and the saponified product), is most important to assure success. The rate of the saponification with sodium hydroxide present in equivalent amount varies approximately with temperature. The reaction is complete in approximately 22 sec. at 500 deg. F., and 6.5 sec. at 554 deg. F. whereas about four hours is required at 212 deg. F. Glycerides and fatty acids are heat sensitive materials, especially at temperatures higher than those that prevail in kettle boiling of soap. Decomposition of these materials is a function of time and also increases markedly with increase in temperature. It is therefore imperative that these materials be heated rapidly in a closed system away from air, and that saponification should be practically complete when the reaction mass reaches high temperature to avoid danger of discoloration owing to presence of unsaponified fat. Properly proportioned amounts of oil and alkali solution must therefore be present at all times with enough alkali present to combine with the glycerides.

One of the achievements of this Clayton process is the rapid removal of glycerine from the soap, which occurs in the molten condition by volatilization. The soap produced by this process is substantially anhydrous, contains about 1.0 percent or less glycerine and exhibits the property of friability.

CONCENTRATED SUPERPHOSPHATE

RAYMOND L. COPSON
Chief of Chemical Research and Engineering
Tennessee Valley Authority
Wilson Dam, Ala.

For many years the manufacture of superphosphate has been a batch process. When TVA undertook to develop the manufacture of concentrated superphosphate by the use of electric furnace phosphoric acid, batch mixing was adopted in the plant at Wilson Dam, Ala. Finely ground phosphate rock and phosphoric acid (74 to 78 percent H_3PO_4) were weighed separately in batches and were mixed in a batch mixer. The product, often called double or triple superphosphate, contained 44 to 48 percent available P_2O_5.

The product was dry enough to be stock-piled within a few minutes after mixing, and neither extended curing nor

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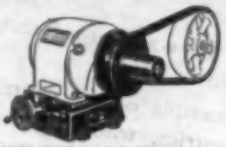

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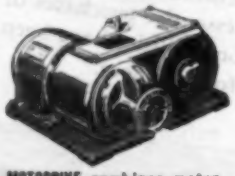

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artificial drying was necessary. However, powerful mixing machines were required and maintenance of the mixers was expensive.

The batch mixing process as used at TVA was described by Curtis (*Chem. & Met.*, Sept. 1935, pp 488-91), who also pointed out the probable advantage of a continuous process and described work on development of such a process.

When the raw materials described above are mixed rapidly, the mixture remains fluid for about 30 sec., then becomes plastic and changes to a hot, moist solid in a matter of two or three minutes. These changes occur much more rapidly than when sulphuric acid is used. The possibility of accomplishing the mixing during the very short period while the mixture is fluid was studied by Copson, Newton, and Lindsay (*Ind. Eng. Chem.* 29, 175, 1937) who gave a flow diagram of a continuous mixing process.

Development since that time has consisted of the adaptation of equipment for automatically controlling the rate of feed of raw materials, simplification of the mixing unit, and increase in capacity.

In the present installation, finely ground phosphate rock is supplied to the mixer by means of a weigh-feeding conveyor unit which automatically regulates the rate and records the amount supplied. The rate of flow of phosphoric acid is controlled automatically by means of a stainless steel rotameter with a magnetic coupling device, a recording controller, and a controlled valve. By adjustment of this equipment, the rate of production may be varied from about 15 to 35 tons per hour.

In the development of a high-speed mixer, difficulty was caused by adherence and solidification of the mixture upon the blades and inner surfaces. By experimentation, a mixer was developed to handle this material satisfactorily.

From the mixer, the mixture falls onto a moving rubber belt where it quickly sets to a solid mass. The rubber belt conveyor is inclosed in a housing from which fumes are exhausted. After remaining on the belt a few minutes the product falls onto a pan conveyor, then goes to a bucket elevator and is conveyed to storage. It reaches the storage pile in the form of small solid lumps. Recovery from storage, disintegration, screening and bagging are the same operations as with batch-processed material.

This development has indicated that continuous production of concentrated superphosphate is entirely practicable. In comparison with batch-mixing, the continuous process is characterized by lower costs for labor, power and maintenance, and can be made practically automatic in operation.

FAT SPLITTING

OSCAR H. WURSTER
President, Wurster & Sanger, Inc.
Chicago, Ill.

Aqueous saponification or hydrolysis of fats has been carried out exclusively by various batch processes until quite recently.

First commercial fat splitting was done in autoclaves in which the mixture of fat

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and water was heated by steam under pressures of 100 to 150 lb. per sq. in. As copper was the only suitable metal of construction, the size of the autoclaves was limited by practical considerations to maximum charges of about 6,000 lb. fat. In most cases a basic material such as lime was used as a catalyst and the length of the cycle varied from 8 to 12 hr. Some autoclaves, however, were operated without catalyst over a period of 24 hr.

Second important step in commercial fat splitting was the introduction of the Twitchell process in which slightly acidulated fat is boiled with water at atmospheric pressure with the addition of a sulpho-acid. The boiling is usually carried out in two stages with a minimum time of approximately 30 hours for the complete cycle. Batches up to 60,000 lb. fat are saponified in wood, copper or Monel tanks. The large charges and operation at atmospheric pressure were two decided advantages for the older autoclave process. The greater discoloration of the fat was a disadvantage. Total costs for the two processes were approximately equal.

NEW MATERIALS HELP

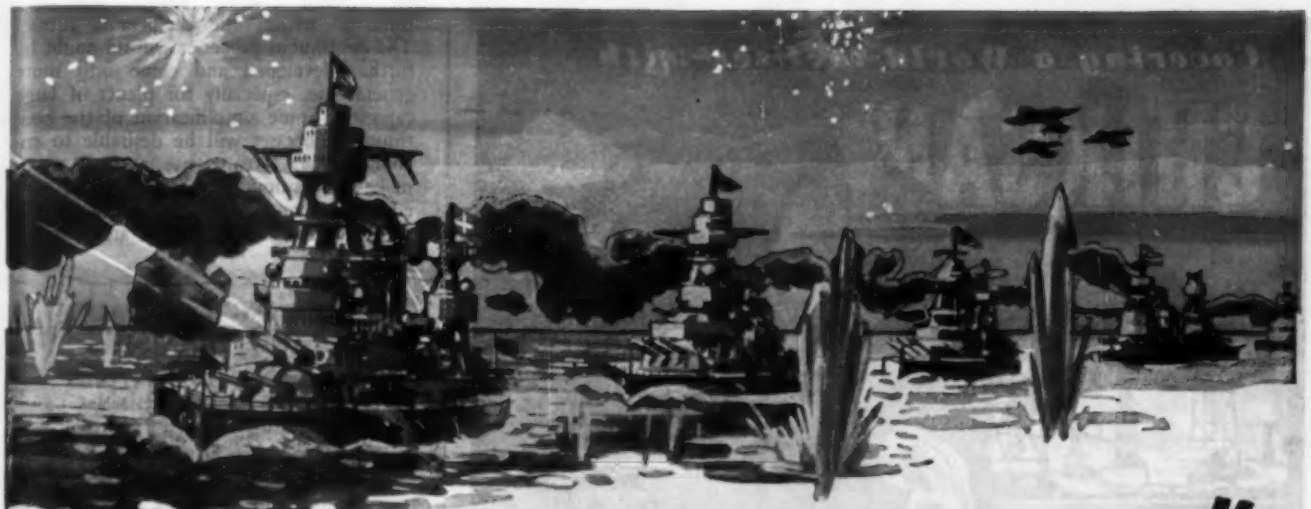
With the introduction of nickel clad and stainless clad steel, there came a new development in the batch autoclave process. These new materials permitted the construction of stronger and larger autoclaves, and vessels were built to take charges of 15,000 to 25,000 lb. and operated at pressures up to 175 lb. per sq. in. A further advance in the autoclave process was made by designing them to operate at steam pressures around 400 lb. per sq. in. The fat is then split without the use of a catalyst. This eliminates subsequent treatment of both the fatty acides and the glycerine sweet-water to remove the catalyst products and effects an appreciable saving in operating cost. Inconel clad steel has also become available as a superior metal of construction for these autoclaves.

At the same time that the high pressure autoclave for operation without catalyst came into use, these new materials of construction made it possible to develop continuous processes of fat splitting at high pressure and temperature with and without catalyst.

There are two types of continuous plants in commercial operation, counter current and parallel flow. In the counter current processes the water is fed in near the top of a vertical reactor vessel, while the fat is fed in near the bottom. The fatty acids then flow counter current to the water and out at the top, whereas the water and glycerine are removed at the bottom. The operating conditions are approximately 250 deg. C. and 800 lb. per sq. in.

In the parallel flow processes the fat and water are mixed, the mixture pumped through tubular heaters and discharged to receivers for the subsequent separation of the fatty acids and glycerine sweet-water. The temperatures used are around 315 deg. C. and the pressure 3,500 lb. per sq. in.

The Twitchell process and the new design high pressure autoclave process are in extensive use and no doubt will con-



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BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
CHIKSAN COMPANY
BREA, CALIFORNIA

tinue so within the predictable future. The continuous processes will no doubt be further developed and come into more general use, especially for plants of large capacity. Some simplification of the continuous processes will be desirable to encourage their greater use as well as to make them suitable for some purposes and conditions, and for some grades of fats for which the batch processes are preferred at present.

PRINTING INK, PAINT AND VARNISH

KENNETH S. VALENTINE
The Patterson Foundry & Machine Co.
New York, N. Y.

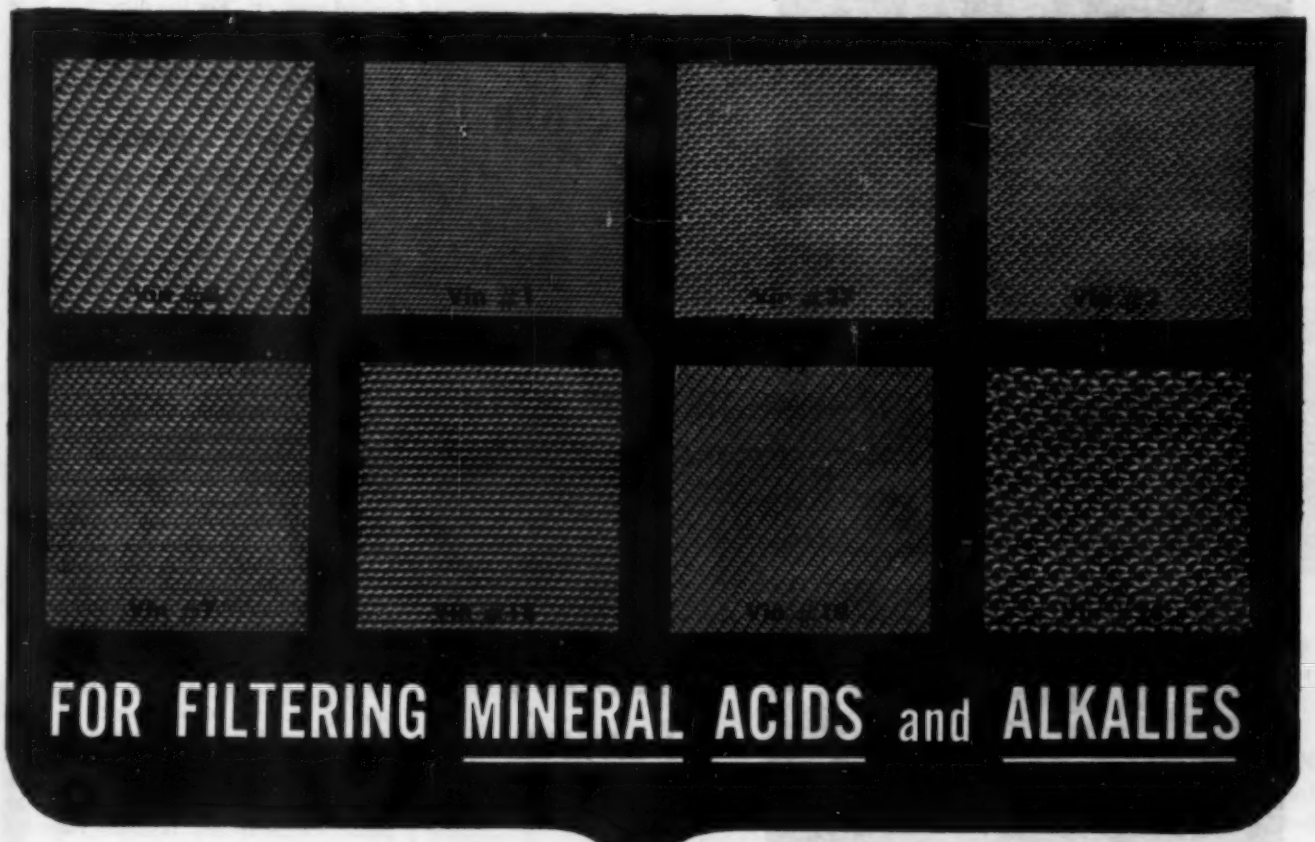
EXCEPT in a few instances, the prospect for continuous processing of printing inks, paints and varnishes is not bright. Too many different shades and too small production of each are the main obstacles. Then, too, there might be ten or more formulas for each shade. One continuous system for each basic color would be the minimum requirement. Cleaning out between runs on different formulas would involve loss. Also, the necessity for filling an empty system and again emptying it at the end of the run would result in substandard material at both ends of the run. Multiply this by the number of formulas, and we see why continuous processing would not be feasible on the general line of products.

However, continuous operation may be applied to individual items, especially those in large production. Although most varnish and synthetic resin is cooked batchwise in kettles, one company operates a patented process whereby a quick-drying product is made continuously. The mixture is passed through pipes in which it is subjected to varying temperatures. It is claimed that the finished product has valuable properties not obtained by any other method. What has been done once can be done again and perhaps better.

There is at present no fully continuous process in the plant-scale manufacture of printing inks, although experimental work is now going on. Rotogravure and litho inks are too varied to lend themselves easily to continuizing. News ink, though, is a fine possibility. Some of the major production is now handled by premixing carbon black and vehicle in batch premixers, then passing through colloid mills with final centrifuging. Except the batch premixing, this process is now continuous. No doubt a way will be found to make the entire process continuous by means of dust-tight continuous weighers for the carbon black and continuous metering for the vehicle, feeding to a continuous mixer.

No paint or lacquer is made by a continuous process. It is true that in one instance, flat whites and perhaps other products are made by passing the paint through a colloid mill. It might also be said that a three or five roll mill operates continuously because the product passes through it or over it. However, a truly continuous process is continuous from beginning to end. Therefore, a continuous paint process would begin with the automatic weighing of the pigment and measuring of the vehicle, would continue with

VINYON* FIBER



FOR FILTERING MINERAL ACIDS and ALKALIES

FILTER FABRICS

If you have a filter fabric problem in connection with any of the processes or products listed below, Vinyon fiber filter fabrics may be the solution. Subject always to certain heat limitations, Vinyon is highly resistant to corrosive fluids.

Perfected and developed through careful field studies, Vinyon fiber filter fabrics are now solving many problems in the filtration of mineral acid and alkali solutions.

Longer life, higher efficiency and therefore ultimate economy are characteristic of Vinyon fiber filter fabrics that will be of interest to you. The engineers on our staff are in a position to discuss with you the possible application of Vinyon fabric to your particular problems. When writing please include all information regarding your present filtration process.

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the premixing (if this were necessary), the dispersion, the thinning and the shading, and would end with the automatic and continuous filling of cans or drums. If the industry is going to give thought to this, attention had better be confined at first to whites and blacks on which there is a large production of a given formula. It can be done. There is an opportunity here for reduction of manufacturing costs, particularly as regards labor and control of finished product. For the dispersion, tube mills would be as well adapted as the types previously mentioned. The thinning operation presents no problem.

RAYON SPINNING

HAYDEN B. KLINE
Vice President, Industrial Rayon Corp.
Cleveland, Ohio

CONTINUOUS spinning and processing of viscose rayon yarn introduced in 1938 at the Industrial Rayon plant in Painesville, Ohio, has demonstrated further its basic advantages over batch processing by its successful adaptation to high tenacity tire yarn production.

Conceived originally to provide a more uniform product through individual thread treatment and elimination of physical handling of the yarn, this process created new industry standards for quality. Not only was a higher degree of uniformity attained but also knots and broken filaments, always a source of trouble to weavers, were reduced to an absolute minimum.

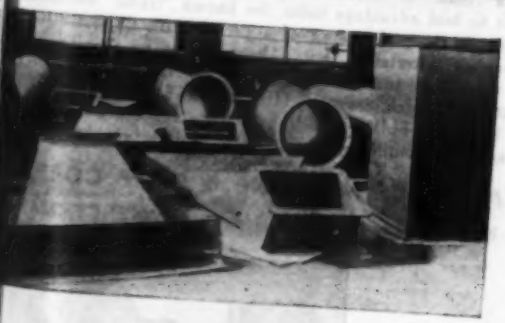
On the continuous process machine yarn is transported from the spin bath by means of specially developed thread advancing reels through a series of operations where it is fully processed and then twisted and collected on rotating bobbins. The process stages include washing, deacidifying, desulphurizing, bleaching, applying emulsion and drying. Individual strands of the yarn, wound as a single layer, are treated with the process solutions as they move across the face of the reel.

With the urgent need of the armed forces for high tenacity yarn to be used in heavy duty and aircraft tires, the company has increased its continuous process production from a prewar annual capacity of 16,000,000 lb. to a current total of 58,000,000 lb. per year.

All tire yarn must be stretched to increase strength and reduce elongation; it must be finished to assist in performing the necessary textile operations and to be prepared for combining with rubber. In conventional methods these operations are performed after the yarn has been wound into a package. In addition to the usual processing operations, this continuous process stretches and finishes the yarn in separate stages before it is wound into a package, thus eliminating an entire extra operation.

In its adaptation for the production of high tenacity tire yarn, the continuous process machine demonstrates the versatility it offers for various branches of the textile industry. The individual thread treatment which it permits can be applied in special processing of yarn such as for crepe fabrics or full fashioned hosiery as well as for industrial fabrics.

MANHATTAN RUBBER LINING



protects your equipment from corrosion, your product from contamination

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MANHATTAN Rubber Lining is widely used on tanks, filters, agitators and troughs, exhaust fans and ducts, dipping cages, vacuum crystallizers, pipes, fittings and many other pieces of equipment in metal finishing, plating, chemical processing and other plants.

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an authoritative study of

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—how we smell, taste and "feel" it

—how flavor is used, tested, and evaluated

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By E. C. Crocker

Arthur D. Little, Inc.
Cambridge, Massachusetts

McGraw-Hill Food Technology Series
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THE book contains a philosophy of flavor, and discussing in turn each of the complex sensory elements of tongue taste, smell, and feeling, develops a practical psychology of flavor perception. It explains fully the physiology of flavor receptors, and the means for stimulating or repressing them to attain desired flavor objectives.

Practical data for food technologists

Gives you detailed discussion of the chemistry of flavoring agents, spices, etc., and methods for developing and retaining them in food and other products, and describes how flavor is influenced by texture, temperature, freezing, dehydration, and other processes. Outlines methods for prevention of undesirable or off-flavors in commercial products, and gives tests for judging and scoring flavor quality in dairy products, meats, ice cream, bread, cake, etc.

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CONVENTION PAPER ABSTRACTS

CONTENTS

Eliminating Bismuth Codeposition. 228
Chemotherapy Progress 228
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ELIMINATING CODEPOSITION OF BISMUTH AND COPPER

IT IS well known that chloride minimizes the loss of silver in copper. It is also well known that chloride minimizes the codeposition of antimony and bismuth with copper. Increasing the chloride concentration in a copper-refining electrolyte up to about 15 mg. per l. decreases the tendency for the codeposition of bismuth with copper. The beneficial effect is greatest at the critical chloride concentration. Above the critical concentration this beneficial effect still exists but is less pronounced.

Of course, actual copper-refining electrolyte is not saturated with bismuth, but the principles still apply. Peculiar to each copper refinery, there is one minimum bismuth content in the copper deposit, corresponding to the quantity of anode slime and the concentration of bismuth in electrolyte. Proper management of the chloride concentration will carry down most, if not all, of bismuth from anodes into anode slime; and the concentration of bismuth in the electrolyte will not be materially increased if the content of bismuth in the anodes is not too high.

The small amounts of chloride purposely added in copper-refining electrolyte have the beneficial effects of minimizing the codeposition of bismuth with copper and refining the crystal size of the copper deposit. While the latter effect is overshadowed by the presence of glue or other addition agent in ordinary copper-refining electrolyte, the former effect is of paramount importance in copper refining. From the shape of the curves of different factors against the chloride concentration in electrolyte, it is concluded that the precipitation of cuprous chloride is the key mechanism. Thus the precipitation of cuprous chloride, which will carry down bismuth with it, together with the well-known precipitation of silver chloride are the chief functions of chloride in copper-refining electrolyte.

Yu-lin Yao, Lehigh University, paper prepared for presentation at 87th general meeting of The Electrochemical Society, Atlantic City, April 12–14, 1945.

PROGRESS AND PROSPECTS IN CHEMOTHERAPY

THE CHEMIST has ever been intrigued with the potency of natural drugs and inquired into the structure of their active ingredients for guidance. The leaves of one of the trees grown in South America was once found to reduce hunger and increase physical endurance. The chemist isolated the active principle, cocaine, in

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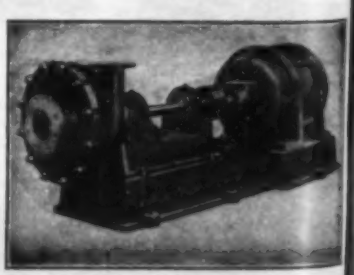

Left—Vertical Pump for handling volatile sludge.

Right — Horizontal Pump mixing and handling sludge.

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of properties which may suggest new applications of

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PURIFIED HYDROCARBON OILS

in your manufacturing processes

THE field of application for purified petroleum hydrocarbon oils, sometimes referred to as white mineral oils, is widening constantly. Exploration of their possibilities is often followed by their adaptation to meet specific requirements arising in the manufacture of new products. Actually, these oils have been for some time replacing ordinary mineral oils or oils of other origin because of certain unusual characteristics possessed by purified hydrocarbon oils.

The recognition of these characteristics of purified hydrocarbon oils — now commercially available — is very often the first link in a chain of events leading to their ultimate adoption for new uses. Among their characteristics are those listed at the right.

These and other characteristics suggest a wide variety of specific applications in many fields and may well hold the solution to one or more problems of your own.

* This is the first in a series of bulletins focusing industry's attention on the possibilities of purified petroleum hydrocarbon oils. The next will appear in an early issue of this publication.

PARTIAL LIST OF CHARACTERISTICS OF SONNEBORN PURIFIED HYDROCARBON OILS

- ☐ No unsaturated hydrocarbons
- ☐ Substantial freedom from aromatic hydrocarbons
- ☐ Composition, predominantly, of saturated paraffins and napthenes
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- ☐ Freedom from color, odor and taste
- ☐ Non-drying
- ☐ Absence of gumminess or stickiness
- ☐ Non-supportive to pathogenic bacterial and mold growth
- ☐ No carbonizable substances
- ☐ Normally non-corrosive and non-sludging

RANGE OF PHYSICAL CHARACTERISTICS

Specific Gravity: 0.775 to 0.895 @ 60°F
Saybolt Viscosity: 30 to 345 @ 100°F.
Distillation Range: 370 to 800°F.
Flash Point: 170 to 420°F.
Fire Point: 190 to 480°F.
Pour Test: +40°F. to −35°F.
Aniline Point: 175 to 230°F.
Refractive Index @ 20°C: 1.43 to 1.48
Dielectric Strength: Above 29 K. V.
Sligh Oxidation Number: 0.0 to 0.9
Copper Stability Test: Not less than 20
Molecular Weight: 175 to 400
Conradson Carbon Test: Below 0.005%
Unsulphonatable Residue: Above 97.5%

Please direct inquiries on specific problems to Department of Industrial Research

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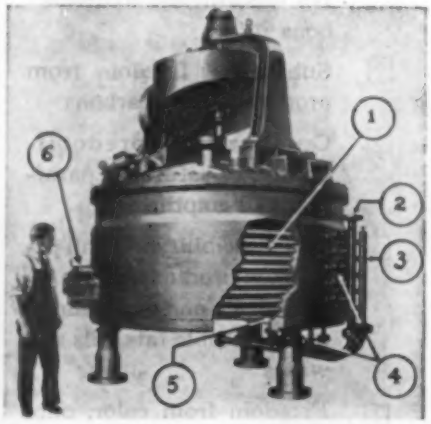
Thermocoil design increases Life of evaporating equipment Five times



1. Coils of steel tubing cast in walls and connected in parallel to supply and discharge headers.
2. Supply header.
3. Discharge header.
4. Flanged header connections to individual coils.
5. Coils cast in flat bottom eliminating stay bolted jacket.
6. Swinging full opening discharge door.

A certain dangerous-to-handle chemical by-product worked havoc with a battery of direct-fired retorts on the processing line, corroded them to destruction in a few months.

Uneven temperatures and spot heating sharply aggravated this hazard. Failures were unpredictable, operation dangerous, production difficult to schedule, complete shutdowns frequent and serious in their effect on costs.

Study of this problem ended in replacing one badly corroded direct-fired retort with a Thermocoil unit. Improvements in heat efficiency rates and notable fuel economies through even temperature control appeared at once.

Ten months later a second direct-fired retort failed and another Thermocoil unit replaced it.

The average experience with these two Thermocoil units, using steam as a heating medium, demonstrates a life-span more than FIVE TIMES the *longest* life of any direct-fired retort previously used in this evaporation.

Here's Why Thermocoil Increases Operating Economy

The steam coils in Thermocoil evaporating, distilling and drying vessels are integral parts of the wall, giving a continuous bond between wall and coil, as illustrated in the cut-away photo. They heat the entire wall surface uniformly from bottom to top. No hot spots. Precise temperature control. No spoilage of product in process. Notable heat economies.

Ask a Bethlehem engineer for the proved facts about these and other features of Thermocoil evaporating, drying and distilling units.

If you want more information preliminary to a talk with us, send for the complete Bethlehem catalog, which covers Thermocoil units, Bethlehem Wedge Roasters, nitrators, reducers, sulphonators, vacuum stills, autoclaves and other Bethlehem-Built Processing Equipment.

BETHLEHEM FOUNDRY & MACHINE COMPANY
Bethlehem, Pennsylvania

1860 and observed its anesthetic action. In 1879, its pharmacological properties were studied and its use as a local anesthetic was recommended. Examination of the chemical structure disclosed certain characteristics, such as the presence of a carboxyl, a hydroxyl and a methyl amino group, which led investigators to prepare simpler compounds which contained them. It was by this procedure that Einhorn found that the simple ester of para-aminobenzoic acid had an anesthetic action and in 1905 synthesized the well known local anesthetic novocaine (procaine). Although many variants of its structure have been made, and many very useful new compounds produced, novocaine still enjoys a high reputation in medical and dental practice. The same story can be developed in other fields of synthetics used in medicinals. The first hypnotics, namely, veronal (barbital) and luminal (phenobarbital) made by the original investigators are still in great repute, the latter having by far the greatest utility.

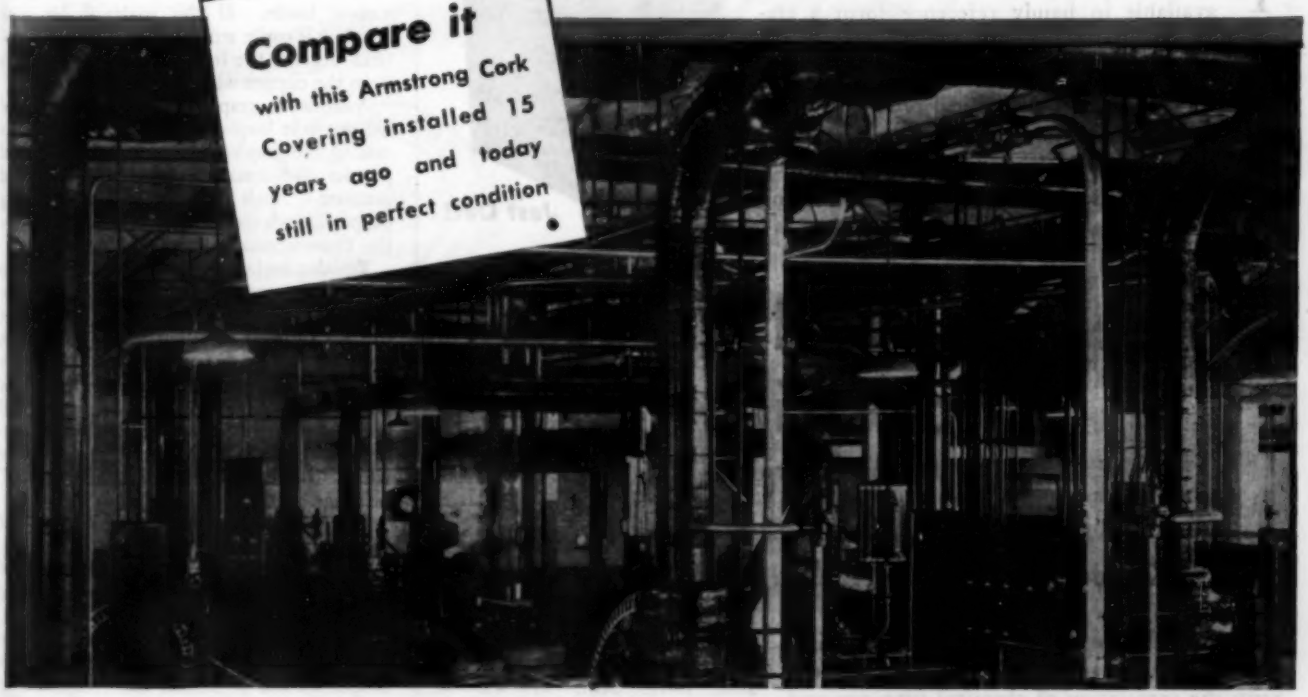
It was only a few years ago that we first heard of the sulfa drugs. The fundamentals of these were initiated again in Europe, where it had been observed that a certain dyestuff had curative action. Inquiry into the activity of the components of the dyestuff brought out the very interesting information that it was due to a simple component, p-aminobenzene sulfonamide. Here came in again the synthetist to vary the structure of this simple compound and produced new substances which improved on the therapeutic usefulness of the parent material. But progress had attained a greatly accelerated tempo so that before the last word was said on the sulfa drugs, penicillin came upon the scene to augment the medical practitioner's armamentarium. Molds were found to synthesize efficient medicinals to supplement the sulfa drugs in some, and surpass them in the case of other diseases. The ultimate utility of penicillin will be gained in time, but sufficient is already known to encourage the belief that its discovery has opened a most promising lead for chemotherapy. Chemists are on the warpath endeavoring to determine its chemical structure and once this is accomplished it will be followed by feverish activity for the synthesis of analogous compounds; and, as history repeats itself, better and more active drugs will be forthcoming. Such diseases as cancer, tuberculosis, leprosy, are still awaiting the discovery of their "miracle" drugs. I believe they will be found. Even the common cold will have its cure. There can be a millenium of well-being and chemists will help make it possible.

Lucas P. Kyrides, Monsanto Chemical Co., Midwest Award Medalist, before St. Louis Section, American Chemical Society, St. Louis, March 5, 1945.

POWDER METALLURGY

Powder metallury is one of the means of mixing metals which do not readily mix in the liquid state. The solid powders are mixed together and the resulting product is pressed into briquets which, in turn, are consolidated into coherent masses by a process known as sintering. Sintering joins the particles together by making millions of minute welds. The sintered product

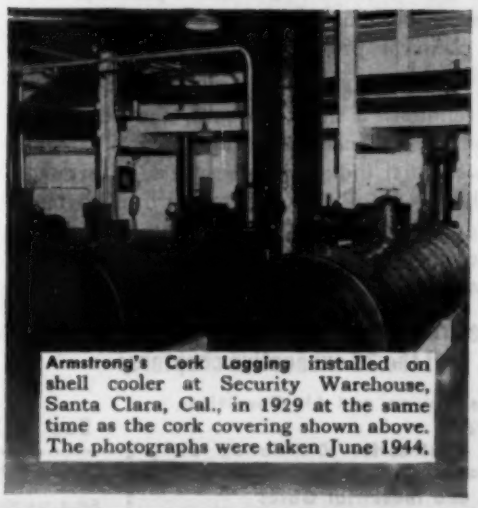
Did you buy any cold line insulation in 1929?



After 15 Years of service, Armstrong's Cork Covering on cold lines in the Security Warehouse and Cold Storage Plant, Santa Clara, Cal., is still solid, dry, efficient. Long, dependable service is typical of Armstrong's Cork Covering, even under the severe conditions encountered in refineries. That's because of molded cork's inherent durability.

Clean granules of pure cork are compressed and baked to make Armstrong's Cork Covering. This insulation has low thermal conductivity and high natural resistance to moisture. It is fire resistant, light in weight, structurally strong.

Armstrong's Cork Covering comes in 3 thicknesses: Special Thick Brine, Brine, and Ice Water—to hold temperatures from 25° F. below zero to 35° F. Each of the three thicknesses is made to fit standard pipe sizes and copper tubing from ¼" up, with fitting covers to match. For full information, write today to Armstrong Cork Company, Building Materials Division, 3305 Concord Street, Lancaster, Pennsylvania.



Armstrong's Cork Lagging installed on shell cooler at Security Warehouse, Santa Clara, Cal., in 1929 at the same time as the cork covering shown above. The photographs were taken June 1944.

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Your comprehensive guide to the chemical process industries

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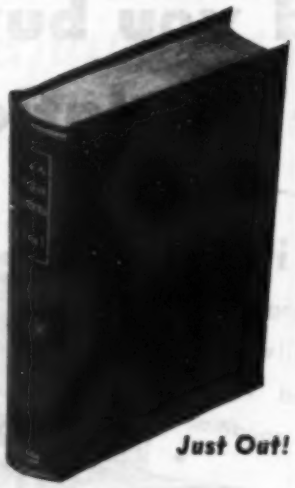

Just Out!

THIS important new 957-page manual makes available in handy reference form a tremendous compilation of authoritative data on the most modern procedures used in the manufacturing of chemicals and chemical products. Here you have a cross-section of the chemical process industries, with the basic procedures for each analyzed and described by flow sheets showing the unit processes and unit operations.

The Chemical Process Industries

By R. Norris Shreve

Professor of Chemical Engineering, Purdue University

McGraw-Hill Chemical Engineering Series

957 pages, 5¾ x 8¾, 256 illustrations, $7.50

THIS excellent one-volume treatment gives the chemical engineer a broad acquaintance with the correlation of chemical processes and physical operations as they are applied to various chemical process industries in many diverse fields.

Definitely a new approach, the book follows closely modern factory practice, and shows actual industrial procedures, illustrated by hundreds of flow sheets, with important integrated material on equipment, costs, raw materials, etc., and with typical problems to be worked out.

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may be used as sintered or it may be the starting material for wrought products such as wire, sheet, tubing, etc. Powder metallurgy offers the means of mixing metals that melt at very high temperatures. It also provides a means of mixing metals and non-metals in proportions which would be impossible by the conventional processes. For example, so-called "friction" material can be incorporated into a coherent mass consisting mostly of powdered copper. The powders are mixed and the mass is consolidated under heat and pressure below the melting point of copper and the friction caused can be controlled within narrow limits. If this material be now fused, it is quite worthless as a friction material because the friction material separates from the copper when the copper melts.

A lubricant, graphite, can be incorporated within wide limits into a metallic mass by mixing the graphite powder and the metal powder and consolidating under heat and pressure. Such material has lubricating properties which cannot be duplicated by the conventional alloying methods.

Powder metallurgy also may be used to control the porosity of the final metallic body. The heat and pressure treatment can be stopped at such a point that the metal is not only porous but the pores will be largely inter-connecting. These pores can be filled with a lubricant and such lubricant may feed out gradually during the lifetime of a bearing to produce what is sometimes referred to as "oil-less" bearings.

A good example of the application of powder metallurgy is the cemented carbide. This material, which consists essentially of hard particles of tungsten carbide sintered with a small quantity of metallic cobalt, utilizes the tremendous hardness of the carbide for cutting and the wear-resistant properties and it utilizes the toughness of cobalt to keep the hard, brittle tungsten carbide in one piece in service.

Another example of the use of powder metallurgy is in the production of tungsten rod and filaments for the lamp, radio, electrical contact and other industries. In this case, the melting point of tungsten is so high that no satisfactory method has ever been found of melting and casting it into ingots. The tungsten powder is produced by reducing tungsten oxide with hydrogen. The powder is pressed into briquets and heated by the passage of electric current to a temperature near 3,200 deg. C. At this temperature the briquet consolidates into an ingot which is then worked into rod and wire. Not only is powder metallurgy practically necessary for shaping tungsten but by adding certain ingredients to the powder, vital grain size control is effected which, so far, has been found impossible to duplicate by the fusion method.

These merely represent a few of the many examples of the present field of powder metallurgy. The scientific and technologic activity in this field is now great. We can confidently look forward to an ever expanding horizon with newer and better products resulting from the application of this interesting process.

Zay Jeffries, General Electric Co., powder metallurgy medallist at Stevens Institute of Technology, Hoboken, N. J., March 7, 1945.

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FOREIGN LITERATURE ABSTRACTS

COMPLEX PLATINUM COMPOUNDS

A SERIES of investigations was started several years ago on complex compounds containing hydroxylamine, bromine and platinum simultaneously. Kurnakov's thiourea reaction was applied for the first time, and successfully, to hydroxylamine platinodiamine bromides to determine their structure. Experimental data showed that this reaction is an exact test for the cis-trans structure and was checked a number of times with the most complex compounds of platinum. Experimental checking of the applicability of Jergensen's rule as well as a deviation of this rule, when cis-platinotetramines are treated with concentrated solutions of hydrobromic acid, was found particularly interesting. Normal reaction products were obtained as well as hydroxylamine complexes of tetravalent platinum and molecular compounds. Jergensen's rule, which has been adopted as a method for determining the structure of complex platinum compounds, was found to be applicable in every case.

A study was made of the double decomposition between complex compounds of the platinodiamine series and potassium bromide. Optimum conditions were found for cleavage of cis-platinotetramines with hydrobromic acid in order to get high yields of platinum hydroxylamine platinodiamine. Reactions between hydroxylamine platinodiamine bromides and pyridine and alpha-aminopyridine, as well as the products of these reactions were studied extensively. More than a dozen bromo-hydroxylamine compounds of platinum, $(Pt.\ 4NH_2OH)Br_n$, were prepared and their properties determined for the first time.

Digest from "Hydroxylamine and Hydrazine Compounds of Platinum and Palladium. IV. Bromides of Hydroxylamine Compounds of Platinum" by V. I. Goremykin and K. A. Gladyshevskaya, *Zhurnal Obschei Khimii*, XIII, No. 11-12, 762-779, 1943. (Published in Russia.)

CHILEAN CHEMICAL INDUSTRY

CHILE'S chemical industry can be divided into (1) chemical manufacturing companies composed of large plants producing saltpeter and iodine for export, and the comparatively small plants working with various mineral, vegetable and animal raw materials; (2) chemical manufacturing industries which consume the greater part of the imported chemical products. This country's chemical industry is run entirely on national capital. There has been considerable expansion in variety and quantity of products since 1936. In 1922 the value of chemical products produced in the country was about 140 million cruzeiros, and in 1925 it was 200 million. Since 1936 Chile has produced 25 percent of all the chemical materials and articles which it needs and that proportion is even higher for medicinal and toilet preparations. That year the Chilean chemical industry produced sufficient hydrochloric and sulphuric acids, sodium bi-

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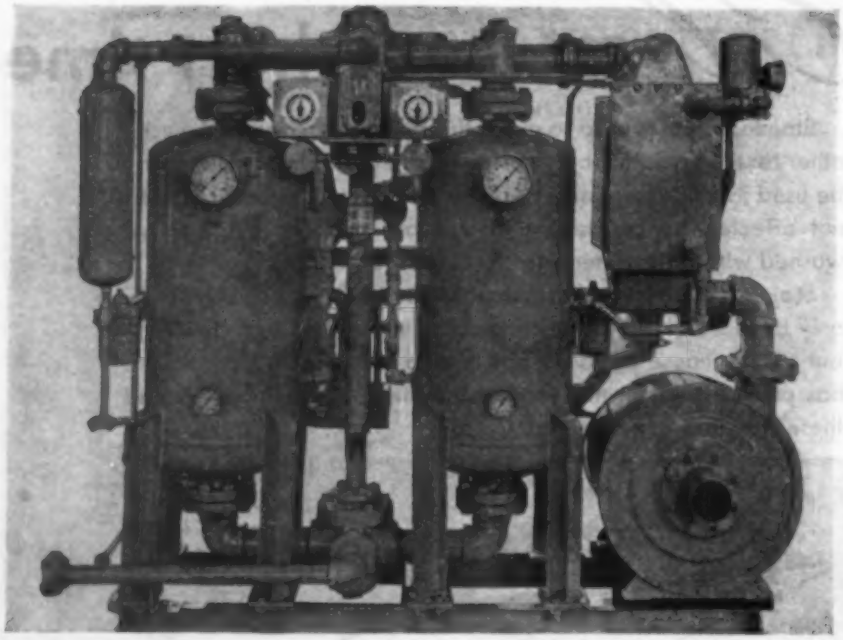
Other interesting uses of stainless steel are described in ELECTROMET REVIEW, published by ELECTRO METALLURGICAL COMPANY, the Unit of UNION CARBIDE and CARBON CORPORATION that produces alloys for making steel. If you are an executive, engineer, or designer you can be put on the mailing list for ELECTROMET REVIEW by sending your name on your business letterhead to ELECTRO METALLURGICAL COMPANY, Room 328, 30 East 42nd Street, New York 17, N. Y.



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sulphite, borax, magnesium, iodine and other products for its own consumption. A large proportion of the national supply of caustic soda, ammonia, bleaching powder, sodium silicate, leaching compound, potassium iodate and nitrate was also manufactured in the country. The production of sodium sulphate, which is of exceptionally pure quality, has been improved recently and federal engineers have made it possible to produce approximately 100,000 tons annually. The sodium sulphate occurs in nature as the mineral thenardite, and is used in the form of calcium sulphate in the manufacture of glass, in the preparation of sodium sulphide, in dyeing and medicine. Hardly 10,300 tons were exported from Chile in 1941 whereas 62,700 were exported in 1937. The production of sodium chloride was almost 44,452,060 tons in 1940. Calcium borate deposits which had been abandoned for some time were worked again in 1941.

Digest from "The Goal of the Chilean Chemical Industry," *Revista Brasileira de Química*, XVIII, No. 105, 212-214, 1944. (Published in Brazil.)

CHROMATOGRAPHY APPLIED TO EXPLOSIVES

Little attempt has been made so far to apply chromatography to the analysis of explosives. Chief published data are the resolution of isomeric nitrophenols and nitroanilines. Nitrotoluenes and naphthalene substitution products have been separated chromatographically using activated alumina and benzene.

While engaged in the purification of styphnic acid, talc or kaolin adsorbent was pre-digested with dilute acid to remove traces of carbonates and finally washed with water and dried before use. On developing the chromatogram with pure solvent (benzene) there was a clear separation of a red (impurities) and yellow (styphnic acid) layers. The chromatogram was loosened, two layers mechanically separated and the adsorbate recovered in each case by extraction with acetone.

Impure TNT (from pre-sulphitation stage, a reddish-brown substance) was adsorbed on talc. On washing with toluene, the reddish-brown adsorbate remains firm while, on washing with petroleum ether, it is further resolved into cerise and brown layers. On evaporating the solvent from the yellow filtrate, the residue is a yellow solid m.p. 78 deg. C. The adsorbate, on extraction with acetone, yields a red oily residue, probably DNT with isomerides of TNT.

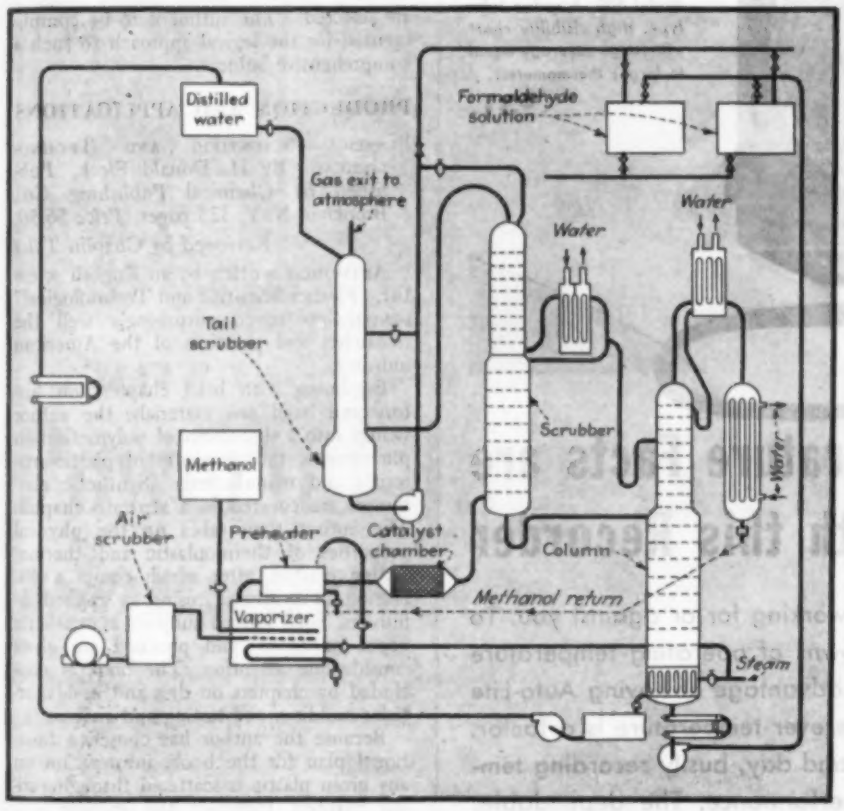
Chromatographic analysis applied to MNT (red liquid) yielded a three-color pattern: red, yellow and violet. Solvent was toluene and adsorbent was anhydrous sodium carbonate. The pattern represents impurities (not identified) the presence of which could not have been suspected.

Tetryl exposed to sunlight is resolvable into tetryl and decomposition products by passing a benzene solution of the irradiated material through a talc column. Tetryl passes into the filtrate while decomposition products are held on the top.

Digest from "Application of Chromatography to Explosives," by B. N. Mitra and M. Srinivasan, Journal of Scientific and Industrial Research, III, No. 7, 300-301, 1945. (Published in India.)

CHEMICAL ENGINEER'S BOOKSHELF

LESTER B. POPE, Assistant Editor



Flowsheet for production of formaldehyde from methanol*

METHANAL, H_2CO

FORMALDEHYDE. *By J. Frederic Walker. Published by Reinhold Publishing Corp., New York. 393 pages. Price $5.50.*

Reviewed by J. R. Callaham

SCIENCE and industry often outstrip by far the written record of their accomplishments and the means by which these are attained. This has been the case with most chemical products and processes. In particular, it has been true of formaldehyde. Within the last two decades this chemical has become a basic organic of industry, yet this present volume is the first in the English language on this subject. Only two works, one in Russian and one in German, have ever preceded it; both are now hopelessly antiquated.

Within this monograph is a wealth of well-documented data on the properties, reactions and uses of formaldehyde. The chapter on production volume and methods of manufacture is interesting but could well contain more information on present-day conditions and practice. Unfortunately, the most recent development in plant expansions, improved operations and new uses of formaldehyde are still considered by certain government officials as confidential military information. It is hoped that in the future a revised edition will contain the missing links.

Otherwise, this volume measures up to about all that could be wished for on the subject. In this connection, it should be pointed out that this monograph makes no attempt to replace the many reference works dealing with formaldehyde resins. Instead, it emphasizes the many other miscellaneous applications which have received less attention in previous publications. All persons interested in formaldehyde and its polymers from the angles of physical properties, chemical reactions, specifications and analyses, derivatives or industrial uses should add this volume to their working libraries as soon as possible. It will prove to be a valuable tool.

* From Walker's "Formaldehyde" from Homer, H. W., *J. Chem. Soc.*, Transactions and Communications, 1941, p. 217 (4T).

OUR MECHANICAL WORLD

NEW WORLD OF MACHINES. *By Harland Manchester. Published by Random House, New York. 313 pages. Price $3.*

Reviewed by George S. Brady

SO MANY books have appeared on the story of inventions and on the wonders of the inventive age that one is apt to treat a new arrival with a sense of wearied question. But no such feeling strikes the reader of this book after he has once picked it up. The author is a roving editor of *Reader's Digest*, and he not only has the facility of writing interestingly, but apparently also knows how to collect interesting facts in his rovings.

The selection of subjects is as good as Mr. Manchester's excellent ability to discuss them. They are the new products that men in all walks of life want to know something about in the coming postwar era—the helicopter, the gas turbine, electronic devices, fluorescent lights, aerial photography, plastics, the diesel engine, synthetic rubber, and the new powder metallurgy. The book attains that rare quality of giving the stories of highly technical subjects in wording and phraseology readily understandable to the layman without being amateurish to the professional. It is a book that anyone interested in the mechanical world about him will profit by and enjoy reading.

CPI REFERENCE

THE CHEMICAL PROCESS INDUSTRIES. *By R. Norris Shreve. Published by McGraw-Hill Book Co., New York. 957 pages. Price $7.50.*

Reviewed by Charles A. Mann

AS STATED by the author, this book is an endeavor to correlate unit processes (chemical change); unit operations (physical change); physical chemistry (equilibrium and reaction rates); economics (cost, statistics and consumption); and energy and power (chemical as well as electrical) as they concern any of the chemical process industries. This approach to the subject is sound and desirable. The results of the author's efforts have been gratifying.

More attention could have been directed to the relations of the unit operations to the various industries considered. It must be assumed, if this book is to be used as a textbook, that the student has previously had a thorough training in the unit operations. The text includes considerable information on materials of construction (particularly from the standpoint of chemical resistance), process instrumentation, safety and fire protection, and refrigeration which could well be taught under a different title than of chemical process in-

RECENT BOOKS RECEIVED

The Chemistry of Acetylene. By J. A. Nieuwland & R. R. Vogt. Reinhold. $4.

Handbook of Pest Control. By A. Mallis. MacNair-Dorland.

Synthetic Rubber From Alcohol. By A. Talalay & M. Magat. Interscience. $5.

Yellow Magic—The Story of Penicillin. By J. D. Ratcliff. Random House. $2.

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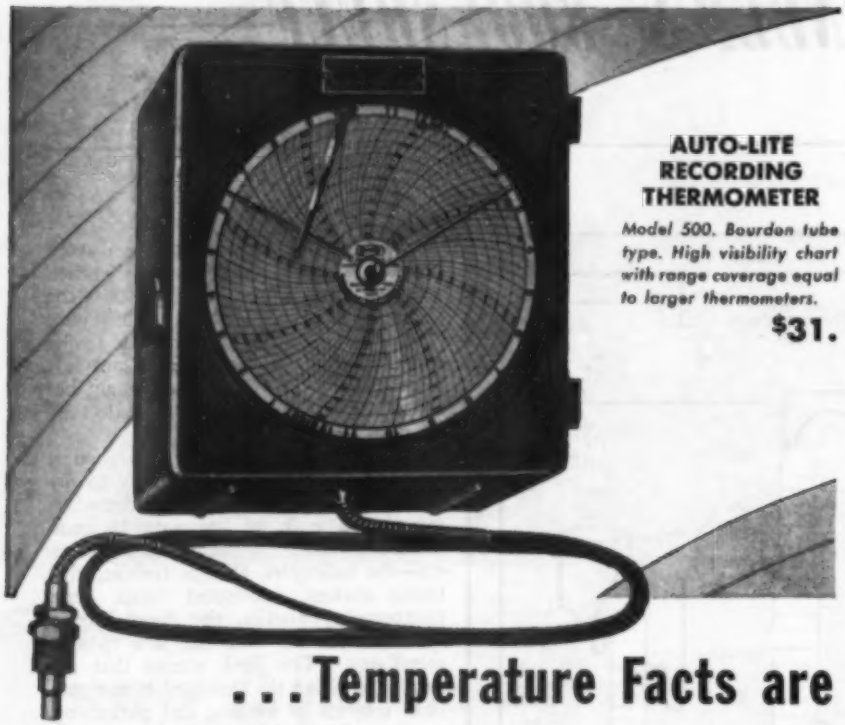

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dustries. Fewer industries considered would make this a more teachable book from the time standpoint. The many flowsheets used are excellent but more discussion on the actual technology involved would improve this book. The inorganic process industries make up one half of this text and the organic industries the remainder.

On the whole the material is handled very well. In its present form it is a better reference book than a textbook for teaching purposes unless specific chapters are selected. The author is to be complimented for the logical approach to such a comprehensive subject.

PRODUCTION AND APPLICATIONS

PLASTICS — SCIENTIFIC AND TECHNOLOGICAL. *By H. Donald Fleck. Published by Chemical Publishing Co., Brooklyn, N. Y. 325 pages. Price $6.50.*

Reviewed by Chaplin Tyler

ALTHOUGH written by an English scientist, "Plastics Scientific and Technological" nevertheless covers surprisingly well the researches and practices of the American industry.

Beginning with brief chapters on history and basal raw materials, the author swings into a discussion of polymerization phenomena, the chemistry of plastic materials and manufacture. Synthetic elastomers are covered in a separate chapter. The author then takes up the physical properties of thermoplastic and thermosetting plastics, after which comes a discussion of synthetic resins as applied to finishes. Such related subjects as synthetic fibers, adhesives, and plywood are given considerable attention. The book is concluded by chapters on dies and molds, articles molding, and testing and analysis.

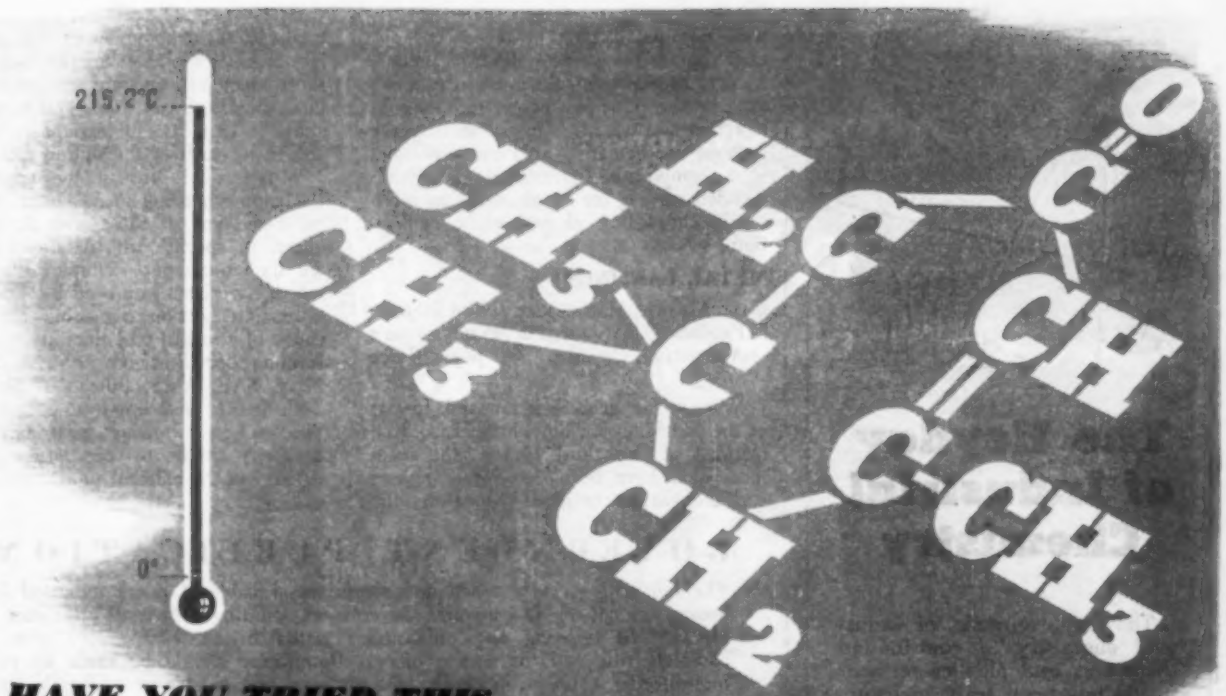
Because the author has chosen a functional plan for the book, information on any given plastic is scattered through various chapters. However, the reviewer concedes the difficulty of organizing such complex subject matter. The degree of accuracy is high, and the author has packed a great deal of matter into relatively small compass.

Some questionable passages were noted. Thus on p. 79 the author says Butacite and other polyvinyl butyrals "are formed by co-polymerization of polyvinyl alcohol and butraldehyde." Actually the polyvinyl alcohol is condensed with butraldehyde, the condensation being a separate step following the polymerization and hydrolysis of vinyl acetate. On p. 226 soybean fiber is said to have about the same tensile strength at break whether dry or wet and is "very resistant to the attacks of molds and bacteria." In the reviewer's opinion this is not an accurate characterization.

GAS TURBINES

THE MODERN GAS TURBINE. *By R. T. Sawyer. Published by Prentice-Hall, New York. 216 pages. Price $4.*

ALL the information that can yet be printed on gas turbines for land, sea and air is in this book which describes modern types of stationary power units, chemical process machines, locomotive and ship drives. The book reviews historical development of the gas turbine over 150 years of inventions. It also includes chap-



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ters on supercharging of diesel and aircraft engines and jet propulsion of aircraft.

Not intended for designers, the book explains the principles of gas turbine construction and operation in simple language without mathematics or thermodynamics of a complicated nature. It is recommended reading for anyone with an interest in the future of gas-turbine application.

METAL CASTINGS

CAST METALS HANDBOOK. *Third edition. Published by American Foundrymen's Association, Chicago. 745 pages. Price $6.*

WHILE the general scope and format of the preceding (1940) edition have been retained in this third edition, the technical data have been extensively revised and brought up to date. As before, the book deals exclusively with the engineering properties of cast metals and divides the subject into separate sections on steel, malleable iron, cast iron, and non-ferrous alloys. Lengthy bibliographies are included for each of the various cast metals.

This is not a treatise for foundrymen, the approach being made rather from the point of view of those who design, purchase, or specify cast metal parts. Thus we find numerous examples of castings which have been improved by redesigning; a separate section discussing the significance of strength and ductility tests; conforming specifications (ASTM, Federal, Navy, SAE, AMS, Bureau of Ships) for both ferrous and non-ferrous metals; and two sections showing what buyers and designers can do to cooperate with foundrymen in the efficient production of their castings.

GOVERNMENT PUBLICATIONS

The following recently issued documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington 25, D. C. In ordering any publications noted in this list always give the complete title and the issuing office. Remittance should be made by postal money order, coupons, or check. Do not send postage stamps. All publications are in paper covers unless otherwise specified. When no price is indicated, the pamphlet is free and should be ordered from the Bureau responsible for its issue.

Agricultural Statistics 1944. Department of Agriculture. Price $1.00.

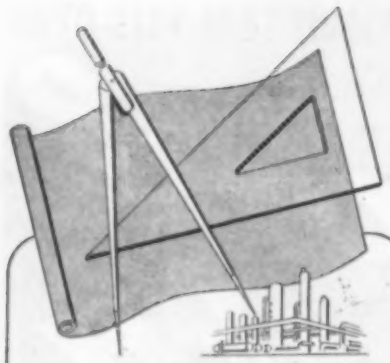
Tray Materials in Relation to Sulfited, Dehydrated Vegetables. Bureau of Agricultural and Industrial Chemistry. AIC-75. Mimeographed.

Magnesium. U. S. Tariff Commission. War Changes in Industry Series Report No. 10. Mimeographed.

Testing of Weighing Equipment. By Ralph W. Smith. Bureau of Standards. Handbook H37. Price 75 cents.

Measurements of Heat Losses from Slab Floors. By R. S. Dill and others. Bureau of Standards. Report BMS 103. Price 10 cents.

Melting and Molding of Ferrous and Non-Ferrous Metals and Alloys. Foundry Man-



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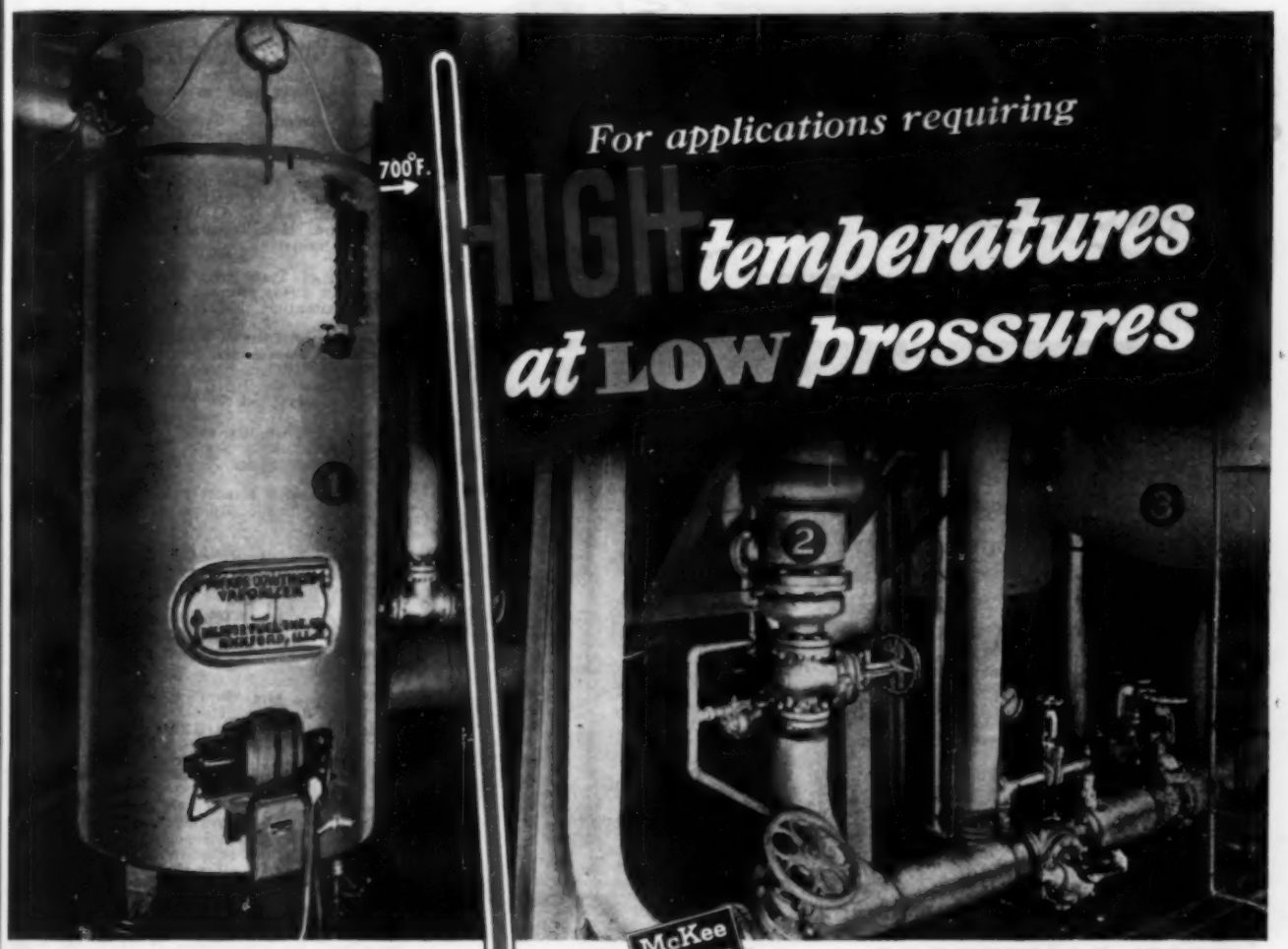

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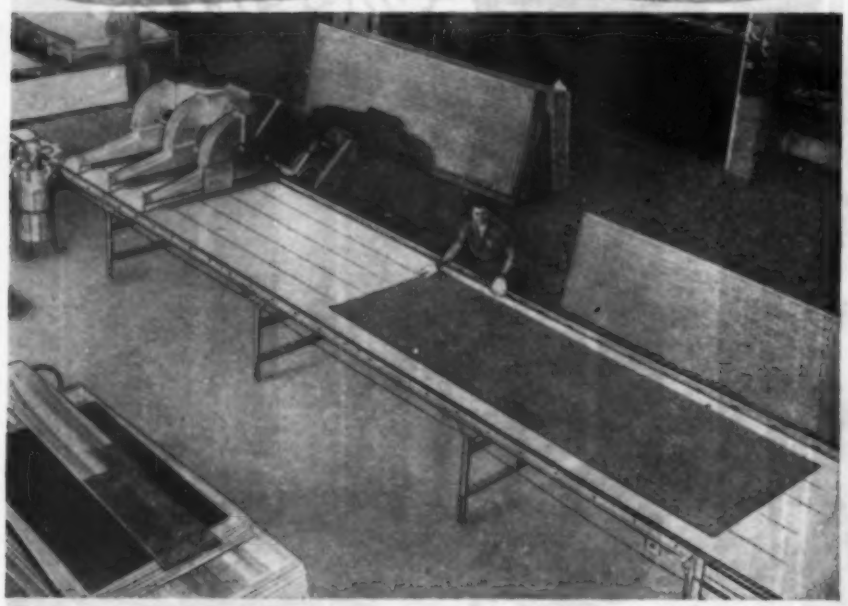

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ual. U. S. Bureau of Ships. Price 45 cents.

Basic Data on the Other American Republics. Office of Coordinator of Inter-American Affairs. Price 30 cents. This is a guide to trade and business opportunities.

South American Leaf Blight of Hevea Rubbertrees. Department of Agriculture. Technical Bulletin No. 882. Price 10 cents.

Insecticides and Equipment for Controlling Insects on Fruits and Vegetables. By N. F. Howard and C. A. Weigel Department of Agriculture. Miscellaneous Publication No. 526. Price 15 cents.

Results of Tests with DDT Against Fruit Insects in 1944. Bureau of Entomology and Plant Quarantine. E-637. Mimeographed.

Preliminary Tests of Synthetic Organic Compounds as Insecticides. Part II. By M. C. Swingle, J. B. Gahan, and A. N. Phillips. Bureau of Entomology and Plant Quarantine. E-634. Mimeographed.

Export-Import Bank of Washington, the First Ten Years. State Department. Commercial Policy Series 75. Price 10 cents.

Comprehensive Export Schedule Number 17. Foreign Economic Administration. Price 50 cents.

Paligorskite. By Robert B. Fisher, Robert L. Thorne and Corbin Van Cott. Bureau of Mines. Information Circular IC 7313. Mimeographed.

Reclaiming Used Pipe for Oil-Field Operations with Cement Lining. By Peter Grandone. Bureau of Mines. Information Circular IC 7314. Mimeographed.

Permissible Mine Equipment Approved During 1944. By A. B. Hooker. Bureau of Mines. Information Circular IC 7316. Mimeographed.

Industrial Reference Service. Bureau of Foreign and Domestic Commerce is resuming issue of its "Industrial Reference Service" pamphlets with the March issue. Part 2 deals with Chemicals, Drugs and Pharmaceuticals, and will be available through the Superintendent of Documents by annual subscription at $2.00 per year. There are six other parts of this periodical which deal with: Leather; Forest Products; Foodstuffs, Fats and Oils; Electrical Equipment; Motion Pictures and Equipment; Transportation Facilities. Each of these parts will be offered for subscription at $1.50 per year.

Report on the Agricultural Experiment Stations, 1944. Department of Agriculture. Price 20 cents.

Annual Report of the Secretary of the Interior, 1944, Post-War Frontiers Edition. Department of the Interior. Price 45 cents. This includes the text of various bureau and subsidiary office reports, including Geological Survey and Bureau of Mines.

A Pattern for Western Steel Production. By H. Foster Bain. Bureau of Mines. Information Circular I. C. 7315. Mimeographed.

Report of the Administrator of Agricultural Research 1944. Department of Agriculture. Price 25 cents.

Explosibility and Fire Hazard of Ammonium Nitrate Fertilizer. Department of Agriculture. Circular 719. Price 10 cents.

Experiments with DDT for Control of Insects Attacking Cereal and Forage Crops in the Field and in Storage. By C. M. Packard. Bureau of Entomology and Plant Quarantine. E-640. Mimeographed.

Tests of DDT Against the Insect Pests of Stored Seed, Grain, and Milled Cereal Products. By R. T. Cotton and others. Bureau of Entomology and Plant Quarantine. E-641. Mimeographed.

Lists of Publications and Patents of Bureau of Agricultural and Industrial Chemistry. Issued during fiscal year ended June 30, 1944. Bureau of Agricultural and Industrial Chemistry. AIC-69. Mimeographed.

Screw-Thread Standards for Federal Services 1944. Bureau of Standards. Handbook H28 (1944) Price 60 cents.

Federal Specifications. New or revised specifications which make up Federal Standard Stock Catalog have been issued on the following items: Oil; lubricating, car and locomotive engine, VV-O-471. Packing; Asbestos, Rod, Braided, HH-P-34a. Packing; Asbestos, Valve Stem. HH-P-51a. Packing Fiber, Animal or Plant; Sheet (for) Lubricating and Fuel-Oil, HH-P-96b. Stain; Wood, Interior, Non-Bleeding. TT-S-711.

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MANUFACTURERS' LATEST PUBLICATIONS

Publications listed here are available from the manufacturers themselves, without cost unless a price is specifically mentioned. To limit the circulation of their literature to responsible engineers, production men and industrial executives, manufacturers usually specify that requests be made on business letterheads.

Adhesives. The B. F. Goodrich Co., Akron, Ohio—32-page booklet describing natural and synthetic rubber adhesives for bonding various materials. This booklet contains a discussion on selection of adhesives together with application information.

Fire Extinguishers. Randolph Laboratories, Inc., 8 East Kinzie St., Chicago 11, Ill.—Illustrated fire extinguisher installation guide showing the type of extinguisher which should be installed and used for different kinds of fires. The various types of extinguishers are pictured and the purpose of each is given. Quantity copies are available now without charge.

Instruments. Builders-Providence, Inc., Providence 1, R. I.—8-page illustrated booklet describing the various features of the mechanical flowmeter built by this company. Comprehensive application data are given and several types of installations are illustrated. Bulletin 318B.

Instruments. Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia 32, Pa.—Publication R-100A. 16-page booklet describing the rotameters built by this company. Features of this instrument together with selection, installation, and application data are given.

Instruments. Precision Thermometer and Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.—Bulletin E. 64-page booklet describing the mercury industrial thermometers made by this company. Application information for various processes and industries with specifications and installation data included.

Pump Valves. Madsen Iron Works, Huntington Park, Calif.—Bulletin RC-1-93. 4-page illustrated leaflet featuring the ball-guided spherical pump valve manufactured by this company. Principles of operation and tables of specifications are given. This valve is designed to handle all types of oil products as well as other types of viscous and non-viscous liquids.

Stokers. The Johnson & Jennings Co., 87 Addison Road, Cleveland 14, Ohio—4-page folder describing this company's spreader type stoker. Bulletin No. 441-S.

Tank Heaters. The Brown Fintube Co., 12 Filbert St., Elyria, Ohio—Bulletin 451. 2-page leaflet illustrating the immersion type steam tank heaters made by this company.

Tube Cleaners. Thomas C. Wilson, Inc., 21 11 44th Ave., Long Island City 1, N. Y.—Bulletin No. 75. 6-page illustrated leaflet covering selection of equipment, proper cleaning procedure, care of cleaning equipment, plus a list of types and sizes of the tube cleaning equipment furnished by this company.

Veterans Programs. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.—40-page booklet discussing the rehabilitation of war veterans prepared jointly by this company and the Wisconsin Society for Mental Hygiene. This booklet should be especially helpful to foremen and supervisors in helping veterans.

Water Treatment. American KAT Corp., 331 Madison Ave., New York 17, N. Y.—9-page technical article discussing internal boiler feed water treatment.

Water Treatment. Water Service Laboratories, 423 W. 126th St., New York 27, N. Y.—4 page folder discussing the internal cleaning of heating boilers.

Wire Cloth. Buffalo Wire Works, Inc., 317 Terrace, Buffalo 2, N. Y.—Catalog 12. 56-page catalog featuring industrial wire cloth. The various types of wire cloth, their features and specifications, together with applications and ordering data are given.

X-Rays. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.—16-page illustrated booklet discussing cathode ray tubes.

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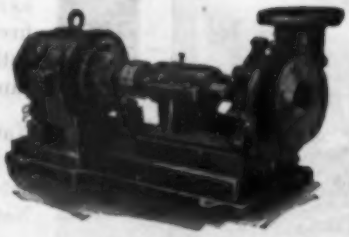

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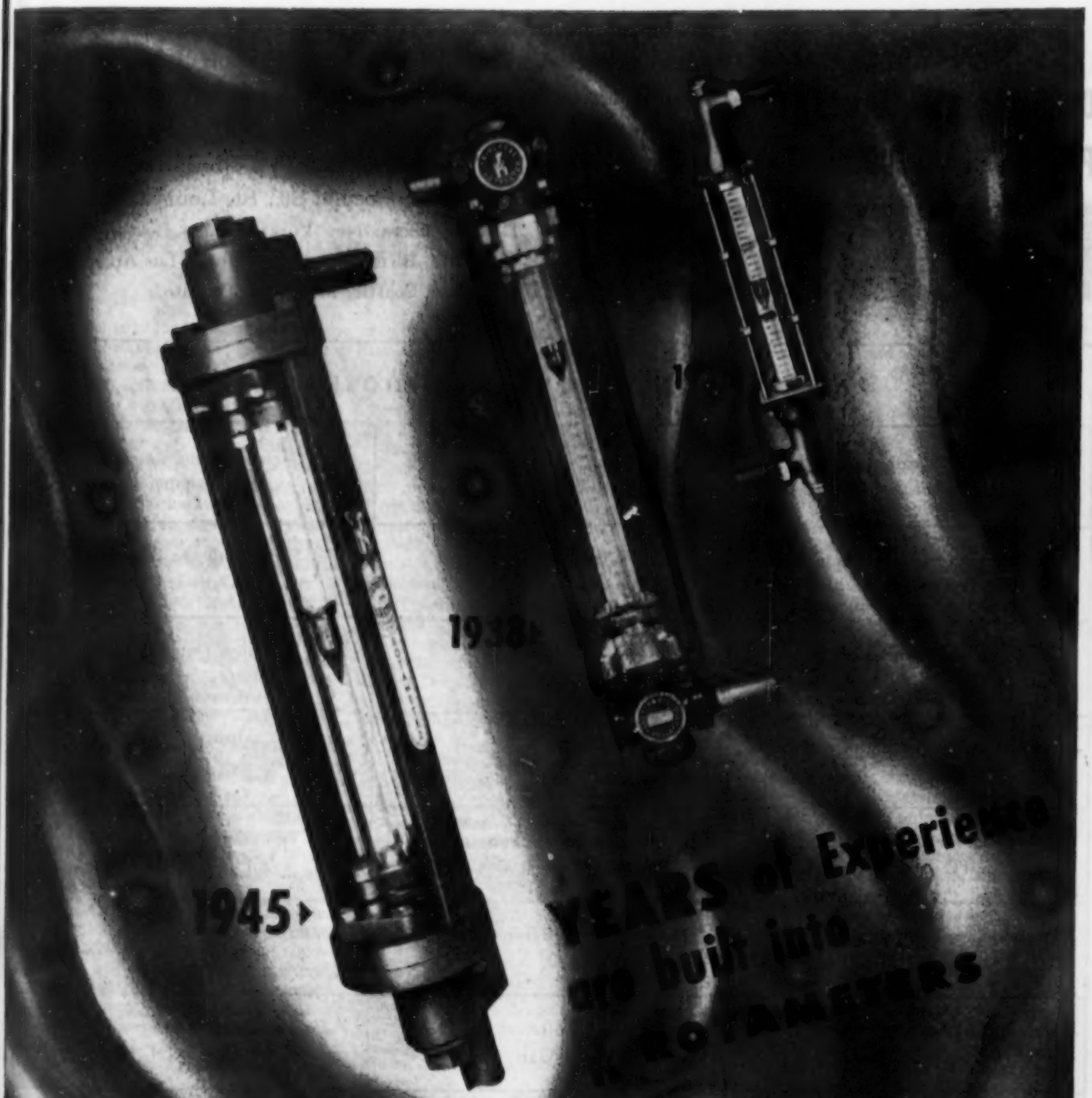

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7. Calcium Acid Pyrophosphate $CaH_2P_2O_7.\times H_2O$	16. Sodium Phosphate Hemibasic $NaH_5(PO_4)_2$	25. Potassium Phosphate-Monobasic KH_2PO_4
8. Calcium Metaphosphate $Ca(PO_3)_2$	17. Copper Pyrophosphate $Ca_2P_2O_7.\times H_2O$	26. Diamylammonium Phosphate $((CH_3.(CH_2)_4)_2NH)H_2PO_4$
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CHEMICAL ECONOMICS

H. M. BATTERS, Market Editor

CHANGES IN WAR STATUS MAY BROADEN INDUSTRIAL REQUIREMENTS FOR CHEMICALS

THE CHANGE in the war situation, accompanied by the almost simultaneous action in announcing cutbacks in production schedules for war goods, presages some decline in the over-all demands for chemicals and other raw materials. By contrast, chemical requirements for civilian goods have not been curtailed and may be increased by an improvement in the manpower supply which will enable many plants to operate at closer to capacities than they have been doing recently.

Another factor in favor of continued high outputs of industrial products is found in the fact that stocks of finished goods are low and there is a heavy backlog of consuming demands which should insure high rates of production for some time to come. Latest available figures also show that producer-stocks of chemicals are, for the most part, of meager proportions. Data for government-operated plants are not made public but so long as high production schedules are maintained at explosives, high-octane gasoline, and synthetic rubber plants, it is not logical to look for any sharp drop in government requirements for chemicals or for the release of large government-owned stocks on the open market.

While data for April are not complete, there appears to have been but little change in industrial consumption of chemicals in the first four months of this year from that reported for the comparable period of last year. Some industries have stepped up their rates of operation and about offset the slowing up in other directions. Incidentally where production has fallen off it has been due to scarcity of raw materials, labor shortage, or some factor other than dimunition of consuming markets. The *Chem. & Met.* index for industrial consumption of chemicals for March is 190.59 which compares with a revised figure of 175.70 for February. Last year the index numbers were 189.49 and 181.14 respectively.

As reflecting on the postwar position of chemicals it is interesting to note that the U. S. Tariff Commission in a study of those chemicals which enter into our import trade, concludes that our postwar production of chemicals, oils, and paints which are on our import duty list, will exceed that of 1939 by more than 60 percent even though our national income returns to the 1939 level. With our national income remaining above the 1939 level, production would be higher accordingly and would double if national income should reach 75 percent above what it was in 1939. While this study does not attempt to establish the rate of increase in domestic consumption of these chemicals, it is evident that consumption would not gain to the same extent as production since some of these products, chlorate of potash for instance, were not produced in this country in the years immediately preceding the war.

In the meantime efforts to enlarge capacities for chemicals for which demand has exceeded supply, has gone forward. Early this month it was announced that an annual production of 190,000,000 lb. of phthalic anhydride would be possible as a result of newly approved plants and plant expansions. Three new plants are nearing completion, that of Standard Oil Co. of Calif. at Richmond, expected to operate in June; that of Koppers Chemical Co., Pittsburgh, expected to start in July; and that of Pittsburgh Coke and Chemical Co. at Pittsburgh, expected to start in August. Each of these plants has an annual capacity of from 7,000,000 lb. to 8,000,000 lb. The most recently approved plant, that of the Barrett Division of Allied Chemical & Dye Corp., at Ironton, Ohio, will have a capacity of 10,000,000 lb. and is expected to be ready for operation early next year.

Additional equipment has been approved for the American Cyanamid plant at Bridgeville, Pa., and for the Monsanto plant at St. Louis, to lift production to 4,500,000 lb. in each plant.

While textile production has been lagging, prospects for a speeding up of operations were seen in steps taken early this month when the industry was told it would be given highest civilian manpower priorities. As a further means to bring about an increase of 25 percent in present production rates official assurance was given that a more advantageous pricing arrangement was being worked out and would be put into effect. Furthermore, attempts to bolster textile outputs are not due entirely to the pressure of military needs but are necessary to stabilize the postwar economy.

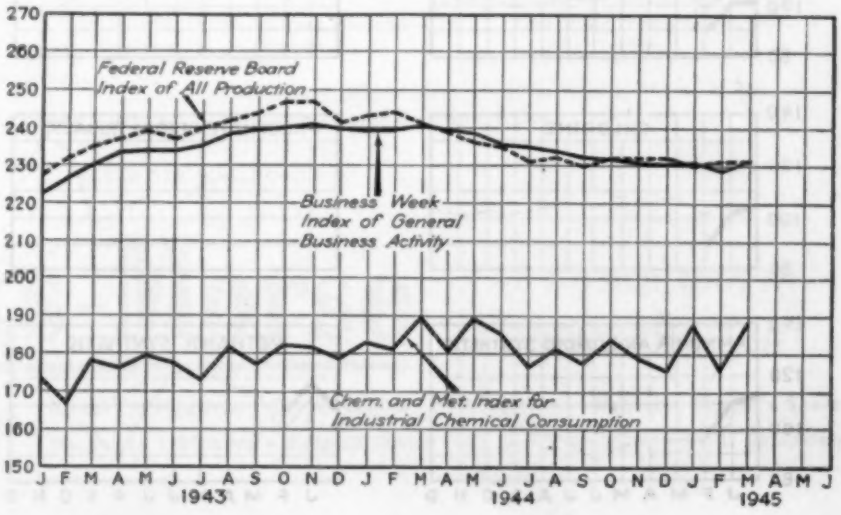
Glass containers, which during the war years have been called upon to shoulder a large part of packaging requirements, apparently have passed their peak period of production. With larger amounts of steel to be made available, the drum supply undoubtedly will be more favorable and later on the packaging field promises to be one in which competition will become increasingly active. As glass containers offer the largest single outlet for soda ash, a material drop in container output will have considerable chemical significance although the certainty of larger production of flat glass will take up a part of this slack.

High-tenacity rayon cord is in a position somewhat similar to that reported for textiles. Facilities for turning out tires have increased more rapidly than that for produring the cord largely because of labor shortage at the cord plants. The postwar picture likewise is similar since civilian demands for tires will call for a continuance of present schedules.

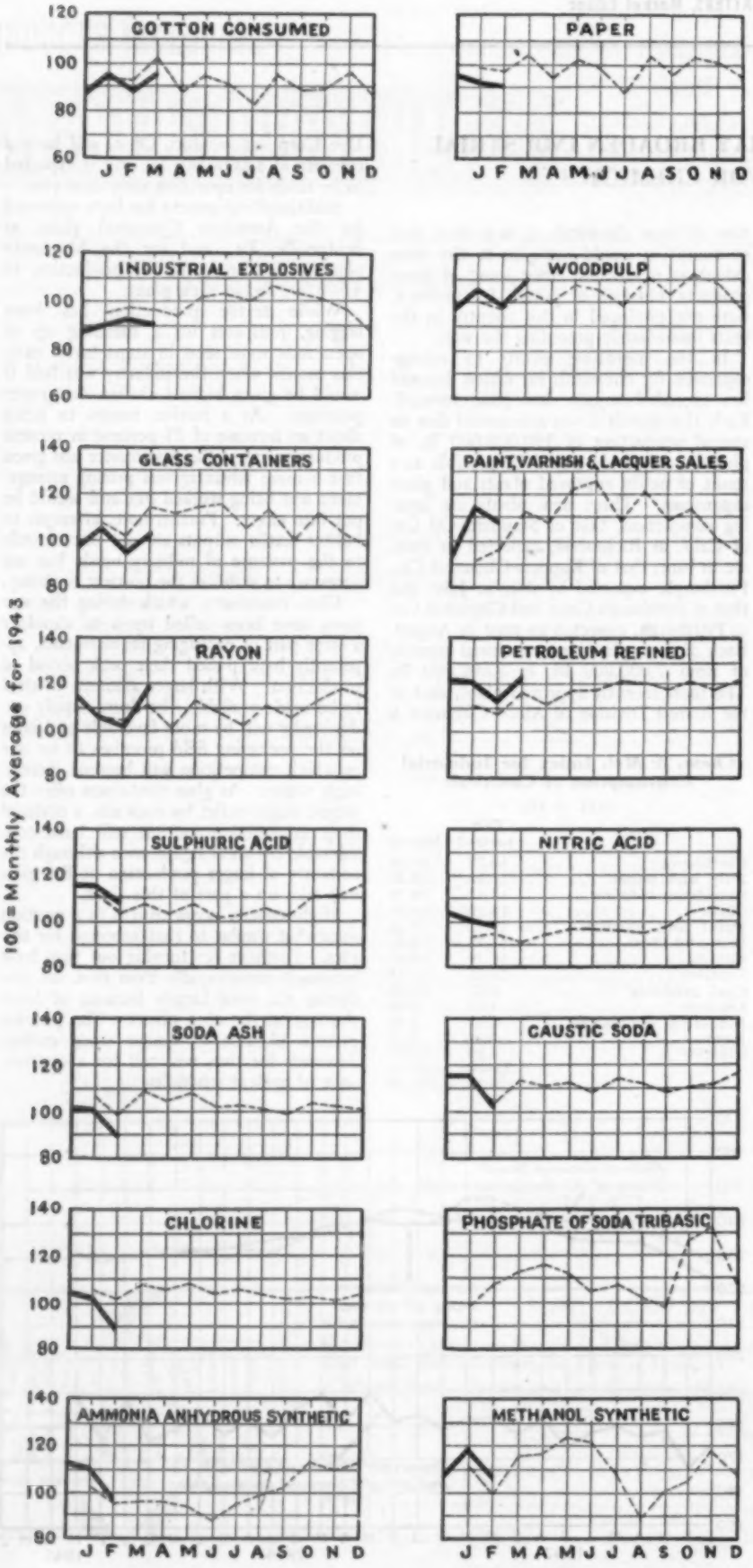
***Chem. & Met.* Index for Industrial Consumption of Chemicals**

1935 = 100

	Feb. revised	March
Fertilizers	40.72	40.98
Pulp and paper	17.72	19.48
Petroleum refining	17.43	19.19
Glass	18.10	19.70
Paint and varnish	16.72	19.38
Iron and steel	11.85	13.62
Rayon	16.30	18.87
Textiles	10.35	11.18
Coal products	9.32	10.50
Leather	4.35	4.60
Industrial explosives	5.04	5.09
Rubber	3.00	3.00
Plastics	4.80	5.00
	175.70	190.59



PRODUCTION AND CONSUMPTION TRENDS



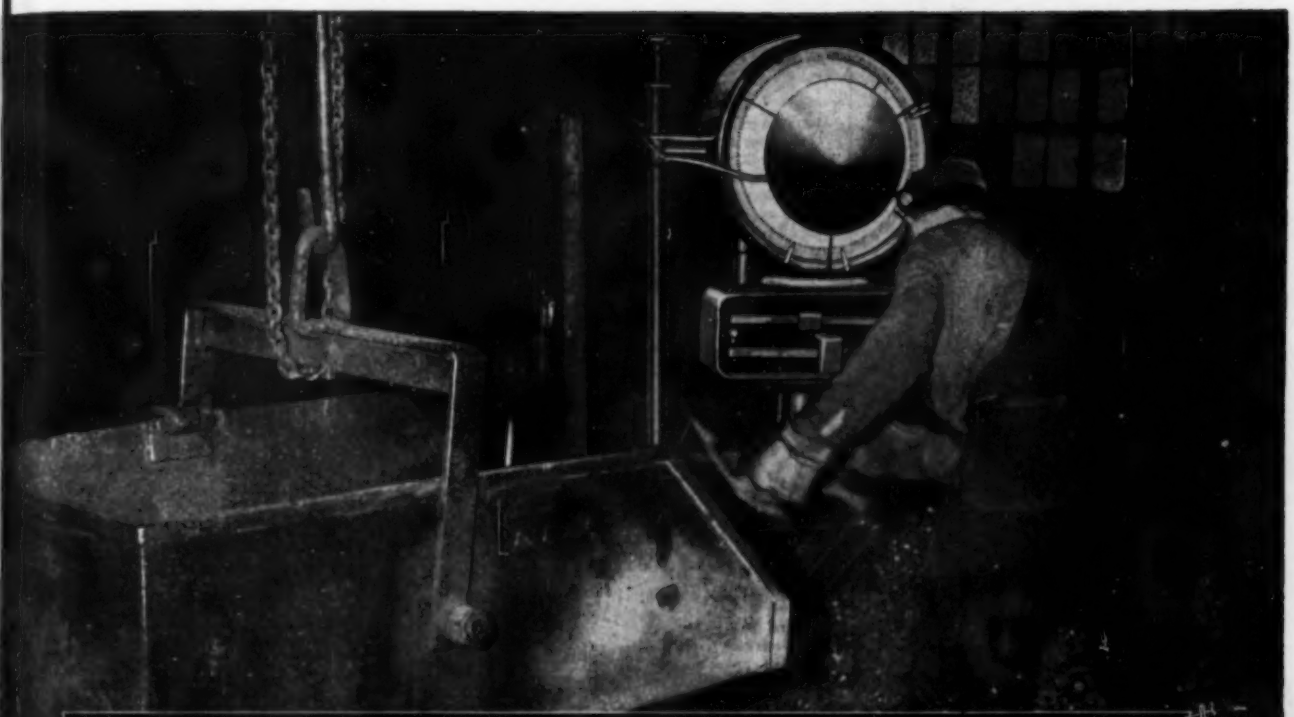
While termination of the war in Europe leaves our war program largely intact, military production in the future will be more selective and will admit of new influences which may be reflected in general industrial lines. Production of war goods already has been under reappraisal with cancellations of those parts of the program which no longer seem necessary. The first effect of these changes will be felt in the re-location of labor forces and this may work out in favor of industrial plants which have been handicapped by the shortage of manpower. Transfer of larger armed forces to the Far East with the longer supply lines to be operated, will require the shifting of large tonnage to those waters but it is probable that some facilities will be given for opening up a two-way trade with Europe.

Most promising prospects in our import trade are found in the possibility of bringing in pulp from Sweden. That country is reported to have large stocks on hand and if a way can be found to move it to this country, our output of paper would be greatly stimulated. Negotiations were in progress early this month to clear the decks for a start of such shipments. Waters around Sweden had first to be cleared from mines so that navigation would be safe. The main feature to be negotiated was concerned with prices and the ceilings now current in this country. Another factor connected with foreign trade has been prominently mentioned and this concerns working out a method of doing business with countries whose currencies have been depreciated.

As an aid to stimulating the movement of copra and coconut oil from the Philippines a contract has been signed between the U. S. Commercial Co., which at present consists of five domestic firms experienced in this trade, and the Copra Export Management Co. formed to procure and ship copra and oil to this country and to operate only during the period when normal trade with the Philippines can not be conducted.

The oils and fats situation has failed to improve according to official surveys and raw material quotas for the soap trade and for the manufacture of edible oils and margarine have been cut for the second quarter of the year. For soap making, bar and package soap, the new ruling permits the use of 74 percent of the oils and fats consumed in the calendar quarters of 1940 and 1941. Perhaps sufficient progress may be made in the way of hastening shipments of copra and oil from Manila to relieve this situation before quotas are established for the third quarter. The purchase of Argentine stocks also will help.

Latest revision in estimates for requirements for alcohol are of minor importance with the total for 1945 now set at 638,000,000 gal. A drop of 10,000,000 gal. from earlier estimates is indicated for use in making synthetic rubber but this is explained as representing greater economies at producing plants and not to any drop in production of rubber.



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- Automatically control weight of aggregates
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- Determine center of gravity of airplanes

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ROYAL CROWN PUMP VALVES were designed upon an entirely new principle—a discovery founded upon the theory that a rigid guide in a pump valve is not capable of resisting the violent flexing side pressures of the fluid in the pump chamber without excessive wear and early failure of the valve itself.

For this reason, the Royal Crown valve is guided by a frictionless ball stem which allows the valve to oscillate and turn at the will of the fluid stream. The Royal Crown valve is a section of a true sphere and seats perfectly in any position. There is no resistance to the fluid—it turns and swings freely with each pump stroke.

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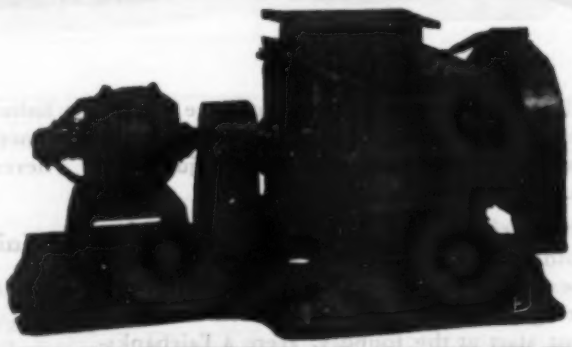
MADSEN IRON WORKS
HUNTINGTON PARK, CALIFORNIA

United States Production of Certain Chemicals

February 1945, February 1944 and Two-Month Totals for 1945 and 1944

Chemical and Basis	Units	February 1945	February 1944	Total, First 2 Months 1945	Total, First 2 Months 1944
Aluminum chloride					
Anhydrous and crystal (100% $AlCl_3$)	M lb.	4,977	.....	10,117	.....
Solution (32° Be)	M lb.	1,094	.....	2,118	.....
Ammonia, synthetic anhydrous (100% NH_3)[1]	Tons	44,756	42,963	94,619	89,4[illegible]
Ammonium chloride (100% NH_4Cl)	M lb.	4,734	.....	9,809	.....
Barium sulphate (100% $BaSO_4$)	M lb.	4,709	.....	9,751	.....
Bleaching powder (35-37% avail. Cl_2)	M lb.	1,909	5,054	3,859	11,[illegible]
Calcium acetate (80% $Ca(C_2H_3O_2)_2$)	M lb.	460	1,055	1,245	2,[illegible]
Calcium arsenate (100% $Ca_3(AsO_4)_2$)	M lb.	1,038	3,857	2,804	6,[illegible]
Calcium hypochlorite (70% avail. Cl_2)	M lb.	1,123	1,178	2,440	2,[illegible]
Calcium phosphate:					
Monobasic (100% $CaH_4(PO_4)_2$)	M lb.	5,312	5,370	10,026	10,[illegible]
Dibasic (100% $CaHPO_4$)	M lb.	3,553	.....	7,102	.....
Carbon, activated	M lb.	4,476	.....	9,545	.....
Carbon black (channel)					
Rubber grade	M lb.	33,898	.....	68,565	.....
Other grades	M lb.	2,502	.....	4,964	.....
Chlorine	Tons	92,086	101,575	196,019	207,[illegible]
Chrome green (C.P.)	M lb.	546	512	1,102	1,[illegible]
Chrome yellow and orange (C.P.)	M lb.	2,978	.....	6,334	.....
Hydrochloric acid (100% HCl)	Tons	33,671	28,591	[2]68,526	57,[illegible]
Hydrogen peroxide (100 volumes)	M lb.	2,537	.....	5,173	.....
Iron blue	M lb.	743	.....	1,550	.....
Lamp black	M lb.	1,086	.....	2,307	.....
Lead oxide:					
Red (C.P.)	M lb.	8,136	8,453	16,047	17,[illegible]
Yellow (C.P.)	M lb.	26,432	.....	56,079	.....
Methanol:					
Natural (80% CH_3OH)	M gal.	270	347	596	72[illegible]
Synthetic (100% CH_3OH)	M gal.	5,527	5,419	12,252	11,[illegible]
Molybdate chrome orange (C.P.)	M lb.	100	124	237	29[illegible]
Nitric acid (100% HNO_3)	Tons	40,067	38,153	[2]80,043	75,7[illegible]
Phosphoric acid (50% H_3PO_4)	Tons	51,128	51,227	[2]103,393	136,[illegible]
Potassium bichromate and chromate (100%)	M lb.	550	714	1,155	1,47[illegible]
Potassium hydroxide (100% KOH)	Tons	3,813	3,362	7,037	6,9[illegible]
Soda ash (commercial sodium carbonate):					
Ammonia-soda process (98-100% Na_2CO_3)					
Total wet and dry[3]	Tons	331,982	363,875	697,670	787,3[illegible]
Finished light[3]	Tons	171,929	201,714	357,445	422,[illegible]
Finished dense	Tons	107,795	113,011	232,743	234,3[illegible]
Natural[3]	Tons	13,880	13,531	28,037	27,3[illegible]
Sodium bicarbonate (100% $NaHCO_3$)	Tons	11,563	13,774	24,166	27,2[illegible]
Sodium bichromate and chromate	Tons	6,400	7,066	12,991	14,1[illegible]
Sodium bisulphite (100% $NaHSO_3$)	M lb.	2,448	.....	5,398	.....

(*Continued on page 254*)



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ROLLING RING CRUSHERS

★ American Rolling Ring Crushers have shown unusual efficiency and economy in crushing chemical raw materials. They have wide operating range, they are simple in construction, low in maintenance and power consumption. The size of each unit is built to meet the particular requirements of an application. The compactness of the unit is an installation advantage and external adjustment is a production advantage. Only the American Rolling Ring Crusher uses the patented reversible manganese SHREDDER RINGS the splitting action of which shatters and distributes the material before it reaches the Breaker and Grinding Plates. We invite you to make use of our testing plant, maintained for prospective customers. Let our engineers recommend the proper equipment for your material. Get complete facts.

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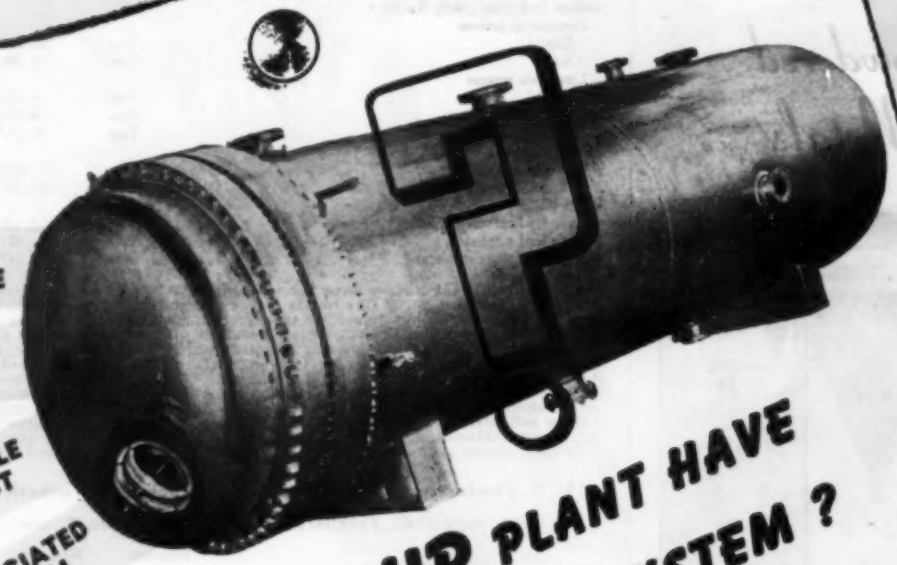

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SINGLE EFFECT

MULTIPLE EFFECT

ASSOCIATED SYSTEM

SHOULD YOUR PLANT HAVE AN EVAPORATOR SYSTEM ?

ONE OF A SERIES OF ADVERTISEMENTS DESCRIBING THE MANY TYPES OF G-R HEAT TRANSFER APPARATUS

The fact that one or more of your neighboring plants do or do not have an evaporator system for distilling their boiler feed make-up may not be a safe guide for you to follow—even if these plants seem to be similar to your own.

Operating conditions, steam demands, quality of raw water supply and plant heat balance—all are factors in determining the advisability of an evaporator installation. These factors are distinctive in each plant and require individual study. Griscom-Russell brings to such a study the accumulated experience of 77 years of pioneering in the development and application of evaporator systems, and the results obtained in many hundreds of evaporator installations.

These are some of the reasons why Griscom-Russell recommendations are authoritative, and why you can depend upon their advice as to the advisability of an evaporator system for your particular plant conditions. Write for complete information, without obligation.

G-R BUILDS ALL THESE UNITS FOR HEAT TRANSFER SERVICE . . .

- Evaporators
- Stage Heaters
- Gas Coolers
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- Jacket Water Coolers
- Process Heat Exchangers
- Transformer Oil Coolers
- Generator Air Coolers
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Pioneers in Heat Transfer Apparatus

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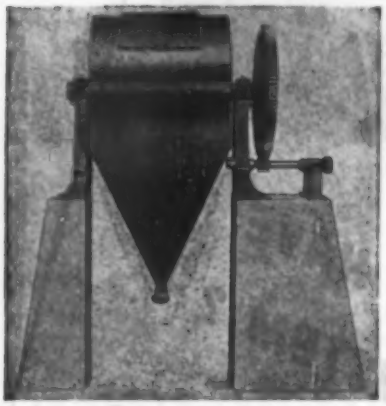

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One of the important developments during the war has been the process of using powdered metals to make many things formerly requiring casting.

•

The new method is said to eliminate flaws due to air pockets and crystallization.

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Paul O. Abbé mills are being used extensively in making the powdered metals for this process, just as they are used in fine grinding of other stubborn materials.

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Sizes in use range from 7 inches in diameter to ninety-six inches.

PAUL O. ABBE

375 Center Street

Little Falls, New Jersey

U. S. Chemical Production (cont. from p. 252)

Chemical and Basis	Units	February 1945	February 1944	Total, First 2 Months 1945	Total, First 2 Months 1944
Sodium hydrosulphide (100% NaSH)	M lb.	1,575	.....	3,285	.....
Sodium hydrosulphite (100% $Na_2S_2O_4$)	M lb.	3,308	.....	6,339	.....
Sodium hydroxide (100% NaOH):[4]					
Electrolytic process					
Liquid	Tons	88,216	94,279	*185,856	194,898
Solid	Tons	18,120	.....	37,581	.....
Lime-soda process					
Liquid	Tons	58,089	53,109	131,399	110,706
Solid	Tons	19,397	.....	39,387	.....
Sodium silicate (anhydrous)	Tons	33,575	.....	71,972	.....
Sulphuric acid (100% H_2SO_4):[4]					
Chamber process	Tons	277,842	284,104	*573,782	571,370
Net contact process[5]	Tons	449,183	407,860	927,953	803,902
White lead:					
Basic lead carbonate	Tons	2,188	.....	*7,206	.....
Basic lead sulphate	Tons	521	.....	1,235	.....
Zinc yellow (zinc chromate) (C.P.)	Tons	1,347	.....	*2,776	.....

Data for this tabulation have been taken from "Facts for Industry" series issued by Bureau of the Census and WPB Chemicals Bureau. Production figures represent primary production and do not include purchased or transferred material. Quantities produced by government-owned arsenals, ordnance works, and certain plants operated for the government by private industry not included. Chemicals manufactured by TVA, however, are included. All tons are 2,000 lb. Where no figures are given, data are either confidential or not yet available. [1] Includes a small amount of aqua ammonia. [2] Total wet and dry production including quantities diverted for manufacture of sodium bicarbonate and caustic soda and quantities processed to finished light and finished dense. [3] Not including quantities converted to finished dense. [4] Data collected in cooperation with the Bureau of Mines. [5] Figures represent total production of liquid material, including quantities evaporated to solid caustic and reported as such. [6] Include oleum grades. Excludes spent acid. * Feb. plus revised Jan. production figure.

U. S. Production, Consumption and Stocks of Synthetic Organic Chemicals

February 1945, February 1944 and Two-Month Totals for 1945 and 1944

Item	February 1945	February 1944	Total, First 2 Months 1945	Total, First 2 Months 1944
Acetanilide, production	490,965	599,572		1,038,720
Consumption	113,101	282,304	197,533	532,672
Stocks	345,319	796,084	345,319	796,084
Acetic acid (synthetic),[1] production	21,914,210	23,835,226	48,238,854	49,069,934
Consumption	19,448,168	17,210,363	39,912,242	36,765,678
Stocks	8,322,696	8,004,120	8,322,696	8,004,120
Acetic acid (natural),[2] production	2,783,514	3,338,767	6,006,055	6,851,081
Stocks	1,738,512	1,509,517	1,738,512	1,509,517
Acetylsalicylic acid, production	816,202	764,095	1,702,704	1,517,892
Stocks	980,175	814,695	980,175	814,695
n-Butyl acetate, production	4,928,093	6,231,619	11,165,769	11,931,063
Consumption	140,658	.....	311,103	.....
Stocks	3,335,700	2,908,377	3,335,700	2,908,377

(Continued on page 256)

READY FOR pH DETERMINATION

PLUG INTO ANY 110 VOLT A.C. OUTLET

The Cambridge pH meter is always "ready-to-go". It may be turned on continuously during the day so that it is available for pH measurements immediately without waiting through a warming-up period to obtain stability. Another feature of the Cambridge is the Electron-Ray Null Indicator. It permits quick, hairline adjustment and cannot be injured by hasty, inexperienced mis-manipulation.

Available in Laboratory and Industrial Models.

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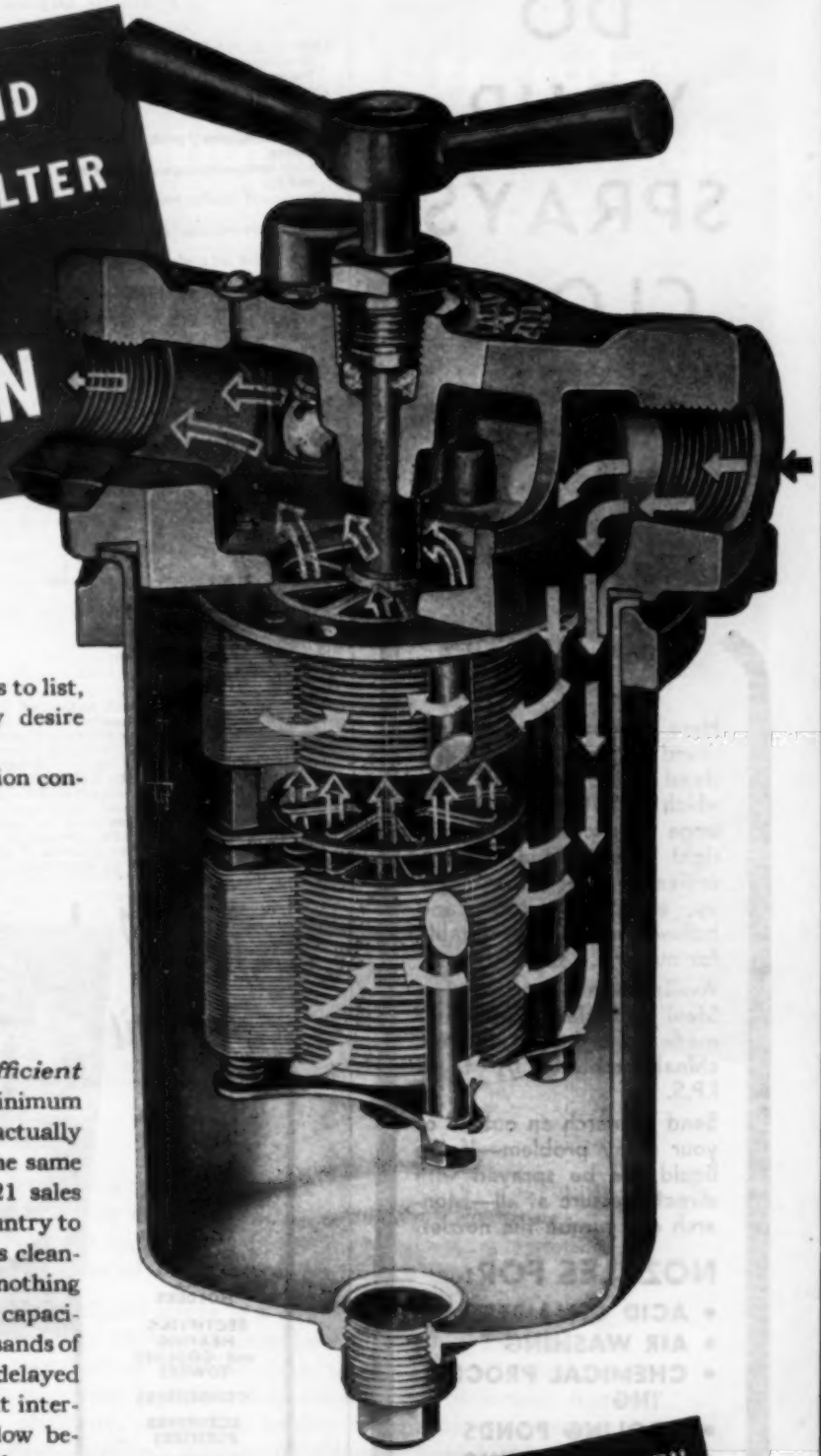
Bump Pumps deliver a constant volume per revolution regardless of speed or pressure . . . positive displacement type that are self-priming under vacuums or against head pressures . . . no agitation, churning, nor vibration take place within the pump . . . available in capacities from ½ to 400 GPM, and models for constant volumes, variable capacities and automatically controlled volumes . . . low maintenance as there are only two moving parts in the pump.

The BUMP PUMP CO.

LA CROSSE • WISCONSIN

WHAT YOU'VE SAID YOU WANT IN A FILTER YOU GET IN AN AUTO-KLEAN



WE asked a large number of manufacturers to list, in order of importance, the features they desire most in a fluid-cleaning device.

Here's what the men in charge of production considered most important:

1. Efficiency
2. Simplicity and compactness
3. Service from supplier
4. Ease of maintenance
5. Capacity
6. Continuous operation
7. Maintenance cost

Now consider the Cuno Auto-Klean. (1) It's *efficient*—positively stops all solids larger than minimum size specified. (2) It's simple and *compact*—actually smaller in size than other filters handling the same volume at equal porosity. (3) There are 21 sales engineering organizations throughout the country to provide service. (4) It's easy to maintain—is cleanable just by turning a handle, or by motor—nothing to replace or remove for cleaning. (5) Flow capacities range from a fraction of a gallon to thousands of gallons per minute. (6) Production is never delayed—the filter is continuously cleanable without interfering with flow. (7) Maintenance cost is low because the all-metal filter element will last as long as the equipment on which it is installed.

Cuno Auto-Klean—an all-metal, non-collapsible filter—is being used successfully on a variety of applications . . . from high-pressure to gravity-feed systems . . . from straining river water to filtering heaviest fuel oil.

You'll find filter selection information and specifications on the Cuno Auto-Klean in SWEET'S—or write us for Mechanical and Process Industries Catalog, Cuno Engineering Corporation, 105 South Vine Street, Meriden, Connecticut.

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DO YOUR SPRAYS CLOG?

Fig. 431

Here is a nozzle with a single round tangential inlet (instead of several small slots) which permits relatively large solid particles to pass right through and out the orifice. Produces fine break-up, even distribution, and hollow cone spray suitable for numerous applications.

Available in Brass, Stainless Steel and Hard Rubber or made to order in any machinable material. 1/4" to 1" I.P.S.

Send Monarch an outline of your spray problem—If the liquid can be sprayed with direct pressure at all—Monarch can furnish the nozzles.

NOZZLES FOR:

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- AIR WASHING
- CHEMICAL PROCESSING
- COOLING PONDS
- DESUPERHEATING
- GAS SCRUBBING
- HUMIDIFYING
- OIL BURNERS
- SPRAY DRYING

Do you have our Catalogs 6A and 6C?

MONARCH MFG. WORKS, INC.

2730 E. WESTMORELAND ST.
PHILADELPHIA 34, PA.

Synthetic Organic Chemicals (cont. from p. 254)

Item	February 1945	February 1944	Total, First 2 Months 1945	Total, First 2 Months 1944
Creosote oil, (tar distillers),[2] production	10,459,296	11,233,805	19,990,920	22,539,766
Consumption	.....	1,013,396	.....	1,824,384
Stocks	10,500,670	22,999,329	10,500,670	22,999,329
Creosote oil (byproduct),[4-6] production	3,065,622	3,228,302	6,096,910	6,201,784
Consumption	16,643	26,021	38,345	196,307
Stocks	894,588	1,711,596	894,588	1,711,596
Cresols (meta-para),[5] production	492,204	648,718	1,186,392	1,211,038
Stocks	268,319	301,729	268,319	301,729
Cresols (ortho-meta-para),[5] production	797,934	758,388	1,533,958	1,343,050
Stocks	.....	335,739	.....	335,739
Cresylic acid (crude), production	1,998,896	2,237,696	4,303,006	4,203,039
Stocks	1,113,439	1,600,935	1,113,439	1,600,835
Cresylic acid (refined),[5] production	2,734,615	2,747,714	5,410,340	5,471,589
Stocks	1,512,182	2,107,819	1,512,182	2,107,819
Diethyl ether (all grades), production	7,109,234	4,217,884	14,730,497	9,184,977
Stocks	3,687,452	2,394,800	3,687,452	2,394,800
Ethyl acetate (85 percent), production	9,145,083	9,016,294	19,172,534	18,930,573
Consumption	1,014,569	1,304,573	2,235,753	2,818,330
Stocks	7,033,794	4,728,573	7,033,794	4,728,573
Lactic acid (edible), production	428,061	268,344	839,806	716,288
Stocks	.....	369,851	.....	369,851
Lactic acid (technical), production	409,890	315,674	826,949	851,812
Consumption	13,902	15,655	31,134	35,964
Stocks	247,813	219,212	247,813	219,212
Methyl chloride (all grades), production	2,267,759	1,317,988	4,650,781	3,609,108
Stocks	581,068	934,563	581,068	934,563
Naphthalene (coke-oven),[5-7] production	6,856,125	9,121,505	14,244,991	18,489,880
Stocks	2,682,260	2,990,248	2,682,260	2,990,248
Naphthalene (tar distillers),[7] production[8]	15,825,833	15,744,644	31,213,188	30,817,457
Stocks	7,609,091	8,270,015	7,609,091	8,270,015
Naphthalene (refined),[5] production	5,355,580	7,788,540	10,736,533	15,036,856
Consumption	4,517,978	4,183,541	8,735,017	8,225,198
Stocks	1,767,348	2,783,416	1,767,348	2,783,416
Oxalic acid (technical), production	1,639,108	1,447,985	3,302,378	2,938,219
Stocks	415,542	784,709	415,542	764,709
Phenobarbital and sodium salts, production	19,806	25,381	40,115	47,845
Stocks	32,568	72,870	32,568	72,870
Phthalic anhydride, production	9,530,915	9,675,900	19,850,417	18,581,343
Consumption	3,188,766	2,621,906	7,110,049	5,192,535
Stocks	1,655,112	1,735,855	1,655,112	1,735,855
Sulfa drugs (total),[10] production	428,951	663,816	806,431	1,317,614
Consumption	.....	237,139	.....	433,243
Stocks	645,345	1,346,134	645,345	1,346,134

Statistics collected and compiled by the U. S. Tariff Commission except where noted. In pounds except that creosote oil is expressed in gallons. Where no figures are given, data are confidential. [1] Excludes recovered acetic acid. [2] Acetic acid produced by direct process from wood and from calcium acetate. Compiled by Bureau of Census. [3] Product of distillers who use purchased coal tar only. [4] Product of byproduct coke-oven operators only. [5] Statistics collected and compiled by Coal Economics Division, U. S. Bureau of Mines. [6] Statistics reported by byproduct coke-oven operators combined with those reported by tar distillers to prevent disclosure of operations of individual companies. [7] Statistics combine three grades: solidifying at less than 74; 74 to less than 76; and 76 to less than 79 deg. C. [8] Production for sale only in case of less than 74 grade. Production both for consumption within producing plant and for sale in case of other two grades. [9] 79 deg. C. and over. [10] Includes data for acetylsulfathiazole, both as drug and as intermediate, resulting in appreciable unavoidable duplication.

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One of the Dresser Industries

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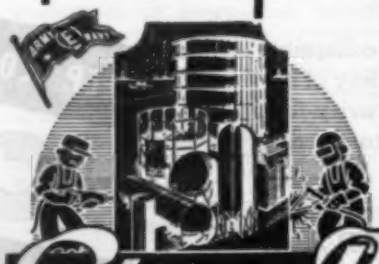

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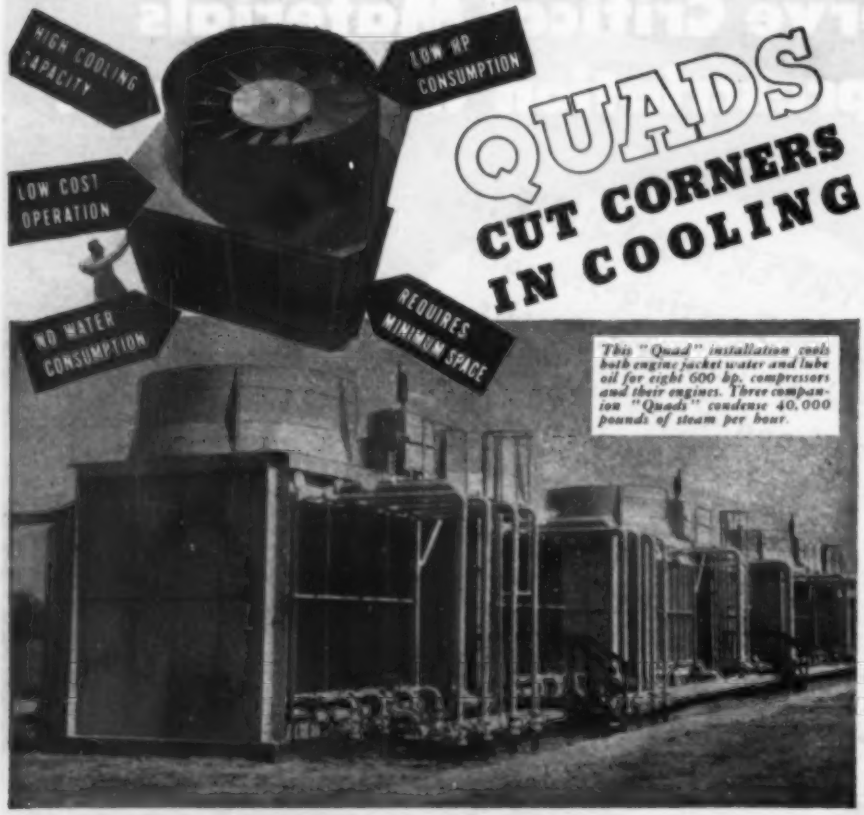
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CHEM. & MET. Weighted Index of Prices for CHEMICALS

Base = 100 for 1937

This month	108.97
Last month	108.93
May, 1944	109.49
May, 1943	108.88

CURRENT PRICES

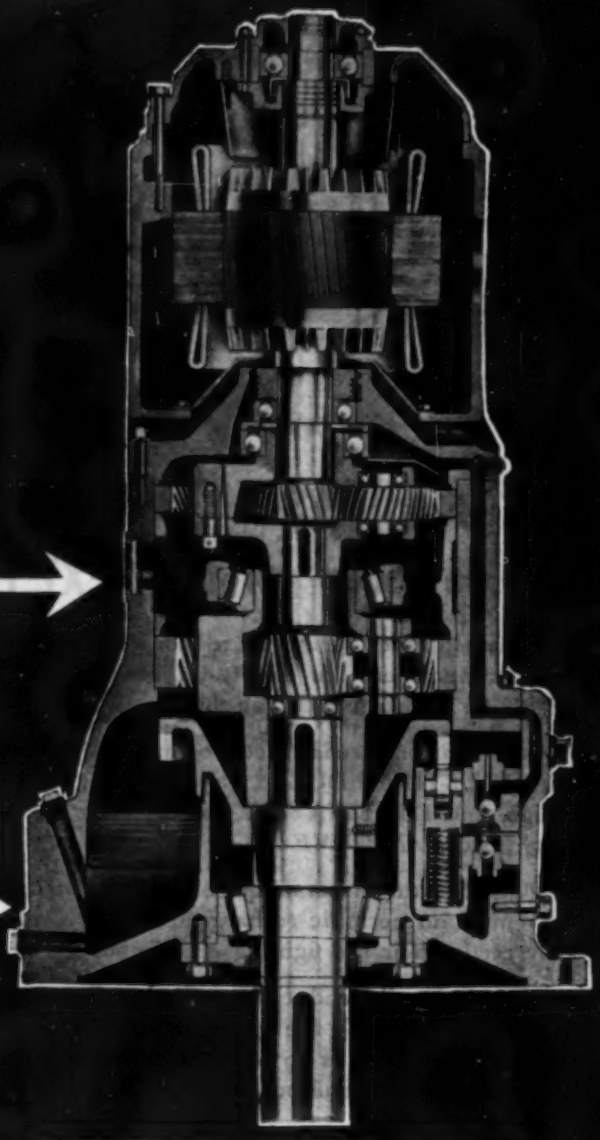
The accompanying prices refer to round lots. Where it is trade custom to sell f.o.b. works, quotations are so designated. Prices are corrected to May 14.

INDUSTRIAL CHEMICALS

Acetone, tanks, lb.	$0.07 -
Acid, acetic, 28%, bbl., 100 lb.	3.38 - $3.63
Boric, bbl., ton	109.00 - 113.00
Citric, kegs, lb.	.20 - .23
Formic, cbys., lb.	.10½ - .11
Hydrofluoric, 30%, drums, lb.	.08 - .085
Lactic, 44%, tech. light, bbl., lb.	.073 - .075
Muriatic, 18°, tanks, 100 lb.	1.05 -
Nitric, 36°, carboys, lb.	.05 - .05½
Oleum, tanks, wks., ton	18.50 - 20.00
Oxalic, crystals, bbl., lb.	.11½ - .12½
Phosphoric tech., tanks, lb.	.04 -
Sulphuric, 60°, tanks, ton	13.00 -
Tartaric, powd., bbl., lb.	.70½ -
Alcohol, amyl	-
From pentane, tanks, lb.	.131 -
Alcohol, butyl, tanks, lb.	.10½ - .18½
Alcohol, ethyl, denatured, 190 proof	-
No. 1 special, tanks, gal., wks.	.50 -
Alum, ammonia, lump, lb.	.04½ -
Aluminum, sulphate, com. bags 100 lb.	1.15 - 1.40
Ammonia, anhydrous, cyl., lb.	.14½ -
tanks, ton	59.00 - 69.00
Ammonium carbonate, powd., tech., casks, lb.	.09½ - .12
Sulphate, wks., ton	28.20 -
Amyl acetate, tech, from pentane, tanks	.145 -
Aqua ammonia, 26°, drums, lb.	.02½ - .03
tanks, ton	65.00 -
Arsenic, white, powd., bbl., lb.	.04 - .04½
Barium carbonate, bbl., ton	65.00 - 75.00
Chloride, bbl., ton	75.00 - 78.00
Nitrate, casks, lb.	.09½ - .11
Blanc fix, dry, bags, ton	60.00 - 70.00
Bleaching powder, f.o.b. wks., drums, 100 lb.	2.50 - 3.00
Borax, gran, bags, ton	45.00 -
Calcium acetate, bags	3.00 -
Arsenate, dr., lb.	.07½ - .08
Carbide, drums, ton	50.00 -
Chloride, flake, bags, del., ton	18.50 - 25.00
Carbon bisulphide, drums, lb.	.05 - .0
Tetrachloride, drums, gal.	.73 - .8
Chlorine, liquid, tanks, wks., 100 lb.	1.75 - 2.00
Copperas, bgs., f.o.b. wks., ton	17.00 - 18.00
Copper carbonate, bbl., lb.	.19½ - .20
Sulphate, bbl., 100 lb.	5.00 - 5.50
Cream of Tartar, bbl., lb.	.27 -
Diethylene glycol, dr., lb.	.14½ - .15½
Epsom salt, dom., tech., bbl., 100 lb.	1.80 - 2.00
Ethyl acetate, tanks, lb.	.11½ -
Formalhehyde, 40%, tanks, lb.	.032 -
Furfural, tanks, lb.	.09½ -
Glaubers salt, bags, 100 lb.	1.05 - 1.10
Glycerine, c.p., drums, extra, lb.	.15½ - .16
Lead:	
White, basic carbonate, dry, casks, lb.	.08½ -
Red, dry, sck., lb.	.09½ -
Lead acetate, white crys., bbl., lb.	.12½ - .13
Lead acetate, powd., bag, lb.	.11½ - .12
Lithopone, bags, lb.	.04½ - .04
Magnesium carb., tech., bags, lb.	.06½ - .06
Methanol, 95%, tanks, gal.	.58 -
Synthetic, tanks, gal.	.24 -
Phosphorus, yellow, cases, lb.	.23 - .25
Potassium bichromate, casks, lb.	.10½ - .10
Chlorate, powd., lb.	.09½ - .12
Hydroxide (c'stic potash) dr., lb.	.07 - .07
Muriate, 80%, bags, unit	.52½ -
Nitrate, bbl., lb.	.05½ - .06
Permanganate, drums, lb.	.19½ - .20
Prussiate, yellow, casks, lb.	.16 - .17
Sal ammoniac, white, casks, lb.	.05½ - .06
Salsoda, bbl., 100 lb.	1.00 - 1.05
Salt cake, bulk, ton	15.00 -
Soda ash, light, 58%, bags, contract, 100 lb.	1.05 -
Dense, bags, 100 lb.	1.15 -
Soda, caustic, 76%, solid, drums, 100 lb.	2.30 - 3.00
Acetate, del., bbl., lb.	.05 - .06
Bicarbonate, bbl., 100 lb.	1.70 - 2.00
Bichromate, casks, lb.	.07½ - .08
Bisulphate, bulk, ton	16.00 - 17.00
Bisulphite, bbl., lb.	.03 - .04

WIDE BEARING SPAN

. . . makes it ideal for overhead agitator drives, impellers, etc.



PHILADELPHIA
MOTOREDUCER

Because the slow speed shafts are mounted on generously spaced tapered roller bearings, the need for objectionable step bearings, in most cases, has been eliminated.

Another advantage of the MotoReduceR is the ring type base which simplifies mounting, when used on tanks or other machinery.

Furthermore, the units are absolutely leak proof . . . no stuffing boxes to leak or maintain. While all parts requiring it receive adequate lubrication, *no oil can leak out* . . . a most important feature for an agitator drive.

The vertical MotoReduceR can be supplied with output speeds from 12 to 450 R.P.M. in sizes from 1 to 75 H.P.

Our catalog MR 45 describing these self contained units as well as the horizontal type MotoReduceR will be sent on request. Please write on your business letterhead.

Philadelphia GEAR WORKS INCORPORATED

ERIE AVE. AND G ST., PHILADELPHIA 34, PA. NEW YORK • PITTSBURGH • CHICAGO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

AND . . . . IN *five* MINUTES

this DUGAS EXTINGUISHER will be ready for the NEXT FIRE!

● You need never be unprepared for a second fire when DUGAS Fire Extinguishers are used . . . because you can *EASILY, QUICKLY* recharge them, on the spot.

As soon as one fire is killed, you have only to refill the chamber with PLUS-FIFTY DUGAS Dry Chemical, slip in a fresh cartridge, and IMMEDIATELY you're ready for the next, which might occur *ANYTIME.*

DUGAS Extinguishers require minimum maintenance, because they need no periodic recharge. In arctic cold or tropic heat, they retain their fire fighting effectiveness.

Easy to handle and operate . . . these portable DUGAS Extinguishers give the fire fighter maximum protection, because the dry chemical rolls up a heat-shielding screen in front of him as he moves in to snuff out the fire.

Constant fire protection like this can be yours. Write today for further information.

Approved by Underwriters' Laboratories, Factory Mutual Laboratories, and Governmental Agencies.

AN ANSUL PRODUCT
duGas
THE MASTER OF FLAME

DUGAS 15-T HAND EXTINGUISHER

DUGAS 150 WHEELED EXTINGUISHER

ANSUL CHEMICAL COMPANY, MARINETTE, WISCONSIN
DUGAS DIVISION

CHEM. & MET.
Weighted Index of Prices for OILS & FATS

Base = 100 for 1937

This month	145.81
Last month	145.85
May, 1944	145.24
May, 1943	146.03

Chlorate, kegs, lb.	.06½ –	.06¾
Cyanide, cases, dom., lb.	.14½ –	.15
Fluoride, bbl., lb.	.07 –	.08
Hyposulphite, bbl., 100 lb.	2.40 –	2.50
Metasilicate, bbl., 100 lb.	2.50 –	2.65
Nitrate, bulk, 100 lb.	1.35 –	
Nitrite, casks, lb.	.06½ –	.07
Phosphate, tribasic, bags, lb.	2.70 –	
Prussiate, yel., bags, lb.	.09½ –	.10
Silicate, 40°, dr., wks., 100 lb.	.80 –	.85
Sulphide, bb., lb.	.02½ –	
Sulphite, crys, bbl., lb.	.02½ –	.02¾
Sulphur, crude at mine, long ton	16.00 –	
Dioxide, cyl., lb.	.07 –	.08
Dioxide, tanks, lb.	.04 –	
Tin crystals, bbl., lb.	.39½ –	
Zinc chloride, gran, bbl., lb.	.05 –	.06
Oxide, lead free, bag, lb.	.07 –	
Oxide, 5% leaded, bags, lb.	.07 –	
Sulphate, bbl., cwt.	3.85 –	4.00

OILS AND FATS

Castor oil, No. 3 bbl., lb.	$0.13½ –	$0.14¼
Chinawood oil, tanks, lb.	.38½ –	
Coconut oil, ceylon, dr. N. Y., lb.	.0885–	
Corn oil crude, tanks (f.o.b. mill), lb.	.12½ –	
Cottonseed oil, crude (f.o.b. mill), tanks, lb.	.12½ –	
Linseed oil, raw, car lots, bbl., lb.	.155–	
Palm, casks, lb.	.0865–	
Peanut oil, crude, tanks (mill), lb.	.13 –	
Rapeseed oil, refined, bbl., lb.	nom.	
Soybean, tank, lb.	.11½ –	
Menhaden, light pressed, dr., lb.	.13½ –	
Crude, tanks (f.o.b. factory) lb.	.09½ –	
Grease, yellow, loose, lb.	.08½ –	
Oleo stearine, lb.	.09 –	
Oleo oil, No. 1, lb.	.11 –	
Red oil, distilled, bbl., lb.	.12 –	
Tallow extra, loose, lb.	.08½ –	

COAL-TAR PRODUCTS

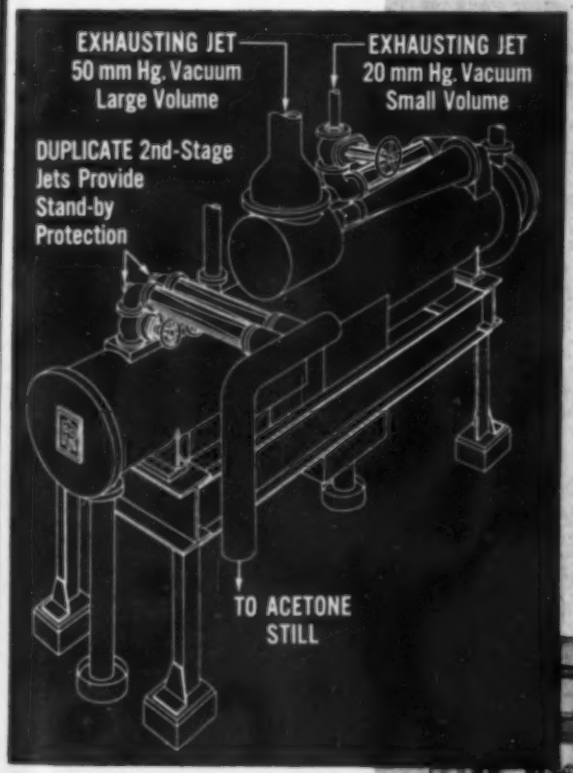
Alpha-naphthol, crude, bbl., lb.	$0.52 –	$0.55
Alpha-naphthylamine, bbl., lb.	.32 –	.34
Aniline oil, drums, extra, lb.	.15 –	.16
Aniline salts, bbl., lb.	.22 –	.24
Benzaldehyde, USP, dr., lb.	.85 –	.95
Benzidine base, bbl., lb.	.70 –	.75
Benzoic acid, USP, kegs, lb.	.54 –	.56
Benzol, 90%, tanks, works, gal.	.15 –	
Benzyl chloride, tech., dr., lb.	.23 –	.25
Beta-naphthol, tech., drums, lb.	.23 –	.24
Cresol, USP, dr., lb.	.11 –	
Cresylic acid, dr., wks., gal.	.81 –	.83
Diphenyl, bbl., lb.	.15 –	
Diethylaniline dr., lb.	.40 –	.45
Dinitrotoluol, bbl., lb.	.18 –	.19
Dinitrophenol, bbl., lb.	.22 –	.23
Dip oil, 15%, dr., gal.	.23 –	.25
Diphenylamine, dr. f.o.b. wks., lb.	.60 –	
H acid, bbl., lb.	.45 –	.50
Hydroquinone, bbl., lbp.	.90 –	
Naphthalene, flake, bbl., lb.	.07 –	.07½
Nitrobenzene, dr., lb.	.08 –	.09
Paracresol, bbl., lb.	.41 –	
Para-nitraniline, bbl., lb.	.47 –	.49
Phenol, USP, drums, lb.	.10½ –	.11
Picric acid, bbl., lb.	.35 –	.40
Pyridine, dr., gal.	1.70 –	1.80
Resorcinol, tech., kegs, lb.	.75 –	.80
Salicylic acid, tech., bbl., lb.	.26 –	.33
Solvent naphtha, w.w., tanks, gal.	.27 –	
Tolidine, bbl., lb.	.96 –	.98
Toluol, drums, works, gal.	.33 –	
Xylol, com., tanks, gal.	.26 –	

MISCELLANEOUS

Casein, tech., bbl., lb.	$0.18 –	$0.23
Dry colors		
Carbon gas, black (wks.), lb.	.0335–	.30
Prussian blue, bbl., lb.	.36 –	.37
Ultramarine blue, bbl., lb.	.11 –	.26
Chrome green, bbl., lb.	.23 –	.33
Carmine, red, tins, lb.	4.60 –	4.75
Para toner, lb.	.75 –	.80
Vermilion, English, bbl., lb.	2.75 –	2.80
Chrome, yellow, C. P., bbl., lb.	.16 –	.17
Gum copal, Congo, bags, lb.	.09 –	.35
Manila, bags, lb.	.09 –	.15
Damar, Batavia, cases, lb.	.10 –	.22
Kauri, cases, lb.	.18 –	.60
Magnesite, calc, ton	64.00 –	
Pumice stone, lump, bbl., lb.	.05 –	.07
Rosin, H., 100 lb.	7.00 –	
Shellac, orange, fine, bags, lb.	.39 –	
Bleached, bonedry, bags, lb.	.39 –	
T. N. bags, lb.	.31 –	
Turpentine, gal.	.91 –	

NOVEL STEAM-JET COMBINATION *Serves* PENICILLIN PRODUCER

One compact two-stage steam-jet exhauster arrangement solved a problem for the Commercial Solvents Corporation's penicillin plant at Terre Haute, Ind. As originally planned, two separate set-ups appeared necessary, since the acetone used to dissolve penicillin culture has to be removed from separate concentrating chambers which are under different vacuums—one at 20 mm Hg abs, the other 50 mm Hg abs. Moreover, considerably more acetone vapor had to be handled by the 50 mm Hg exhauster.

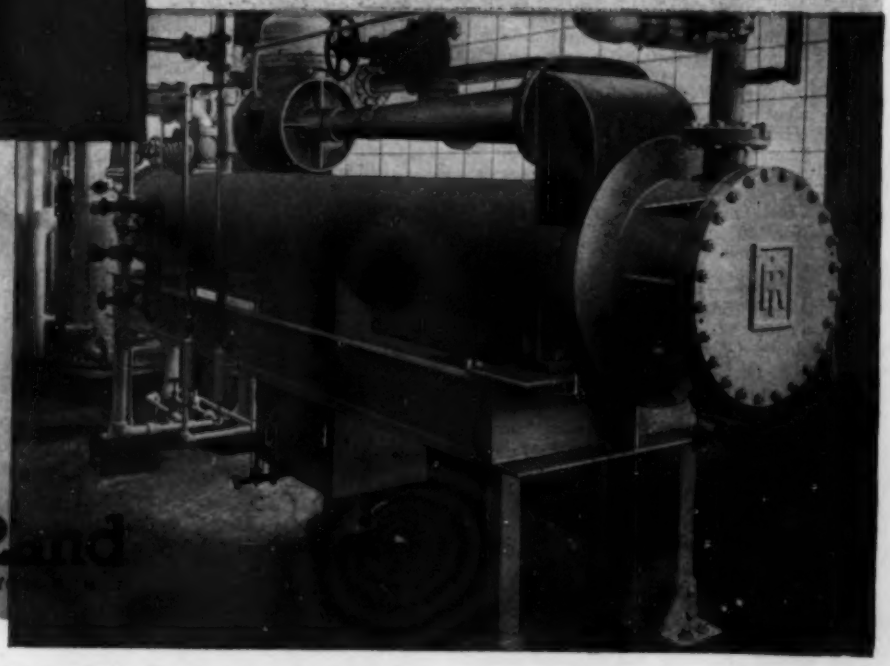


In working with the E. B. Badger Sons Company, engineers for the plant, Ingersoll-Rand vacuum specialists suggested this unusual combination of standard equipment:

Separate exhauster jets remove acetone vapor from the two concentrating chambers. Both of the jets selected have the same discharge pressure so they can exhaust to the same intercondenser, which is a surface-type unit.

Any vapors not condensed by the intercondenser are removed by a second-stage steam jet, which discharges directly into an acetone still.

Ingersoll-Rand has available a complete line of steam-jet ejectors, condensers and related equipment to help solve your commercial vacuum problems. Your inquiry is invited.



AIR TOOLS
ROCK DRILLS
OIL AND GAS ENGINES
CENTRIFUGAL PUMPS
TURBO BLOWERS
COMPRESSORS
CONDENSERS

Ingersoll-Rand
11 BROADWAY, NEW Y

4-638

NEW CONSTRUCTION

	Current Projects		Cumulative 1945	
	Proposed Work	Contracts	Proposed Work	Contracts
New England	$40,000	$465,000	$2,085,000	$785,000
Middle Atlantic	335,000	160,000	4,742,000	11,782,000
South	1,348,000	8,250,000	18,328,000	13,033,000
Middle West	1,000,000	15,040,000	6,875,000	24,091,000
West of Mississippi	8,345,000	175,000	53,270,000	75,919,000
Far West	400,000	500,000	3,600,000	4,250,000
Canada	.....	.....	7,265,000	1,100,000
Total	$11,468,000	$24,590,000	$96,165,000	$130,960,000

PROPOSED WORK

Calif., Emeryville—Oliver Tire & Rubber Co., 4343 San Pablo St., plans to construct an addition to its plant. Irwin M. Johnson, 449 McArthur Blvd., W., Oakland, Archt. George E. Atkins, Hobart Bldg., San Francisco, Engr. Estimated cost $400,000.

Conn., New Haven—Bradley Laboratories, Inc., 82 Meadow St., is having plans prepared by Leo F. Caproni, Engr., 1221 Chapel St., for altering building on Oliver St. for experimental laboratory.

La., Rodessa—Cabot Carbon Co., Rodessa, plans to construct a carbon black plant here to be financed by Defense Plant Corp., Washington, D. C. $1,048,000 has been allocated for project.

Mich., Detroit—Carboloy Co., 11177 East 8 Mile Rd., plans to construct a 1 story factory. Estimated cost $350,000.

N. J., Newfield—Specialty Glass Co., Newfield, plans to rebuild its plant recently destroyed by fire. Estimated cost $150,000.

N. M., Eunice—Phillips Petroleum Co., Eunice, plans to construct additional facilities for carbon black unit or desulphurization plant. Project will be financed by Defense Plant Corp., Washington, D. C. $142,826 has been allocated for project.

N. Y., Long Island City—West Disinfecting Co., 42-16 West St., plans to construct a storage building on West St. and Jackson Ave. Estimated cost $75,000.

N. C., Shelby—Southern Cotton Oil Co., South Morgan St., R. C. Barnett, Gen. Mgr., plans to construct a fertilizer factory. Estimated cost $300,000.

O., Findlay—Master Tire & Rubber Corp., J. F. Schaefer, Pres., Findlay, plans to construct a 100x240 ft. addition to its plant. Austin Co., 16112 Euclid Ave., Cleveland, Archt. and Engr. Estimated cost $650,000.

Pa., Franklin—Franklin Plastics Div. of Robinson Industries, Inc., Franklin, plans to construct a 1 story factory on Grant St. Estimated cost $50,000.

Pa., Harmarville—Gulf Research & Development Co., Gulf Bldg., Pittsburgh, plans to construct a 1 story, 35x53 ft. furnace oil test laboratory. Estimated cost $60,000.

Tex., Beaumont—Pittsburgh Plate Glass Co., c/o J. O. Davis, 101 Crawford St., Houston, plans to construct an addition to its plant. Estimated cost $50,000.

Tex., Borger—Cabot Carbon Co., Borger, plans to construct additional facilities for manufacture of carbon black. Project will be financed by Defense Plant Corp., Washington, D. C. $801,666 has been allocated for project.

Tex., Borger—J. M. Huber, Inc., Borger, plans to construct new carbon black or desulphurization unit here to be financed by Defense Plant Corp., Washington, D. C. $212,400 has been allocated for the project.

Tex., Borger—Phillips Petroleum Co., Borger, plans to construct carbon black or desulphurization unit here to be financed by Defense Plant Corp., Washington, D. C. $139,000 has been allocated for project.

Tex., Clements—Jefferson Lake Sulphur Co., Clements, plans to construct carbon black or desulphurization unit here to be financed by Defense Plant Corp., Washington, D. C. $360,454 has been allocated for project.

Tex., Foster Field—United Carbon Co., Foster Field, plans to construct carbon black or desulphurization unit here to be financed by Defense Plant Corp., Washington, D. C. $139,000 has been allocated for project.

Tex., Goldsmith—Phillips Petroleum Co., Goldsmith, plans to construct carbon black or desulphurization unit here to be financed by Defense Plant Corp., Washington, D. C. $53,000 has been allocated for project.

Tex., North Cowden—Cities Service Oil Co., North Cowden, plans to construct additional facilities here for manufacture of carbon black to be financed by Defense Plant Corp., Washington, D. C. $150,000 has been allocated for project.

Tex., Odessa—Cities Service Oil Co., Odessa, plans to construct additional facilities for manufacture of carbon black here to be financed by Defense Plant Corp., Washington, D. C. $224,000 has been allocated for project.

Tex., Odessa—United Carbon Black Co., Inc., Charleston, W. Va., plans to expand carbon black plant here to be financed by Defense Plant Corp., Washington, D. C. $1,423,000 has been allocated for project.

Tex., Wickett—Cabot Carbon Co., Wickett, plans to construct additional facilities for manufacture of carbon black here to be financed by Defense Plant Corp., Washington, D. C. $150,000 has been allocated for project.

Tex., Yoakum—Shell Oil Co., Inc., Shell Bldg., Houston, plans to construct a recycling plant in this area. Estimated cost $2,000,000.

Tex., Yoakum—Sterling Oil & Refining Co., Sterling Bldg., Houston, plans to construct a recycling plant in this area. Estimated cost $2,500,000.

CONTRACTS AWARDED

Calif., Coalinga—Robert S. Lytle, Coalinga, has awarded the contract for the construction of a gasoline absorption plant to C. F. Braun & Co., 1000 South Fremont Ave., Alhambra. Estimated cost $500,000.

Conn., Derby—Sponge Rubber Products Co., Howe Ave., Shelton, has awarded the contract for a 2 story, 100x315 ft. addition to its factory to Dwight Building Co., 152 Temple St., New Haven. Estimated cost $300,000.

Ill., Lockport—Texas Co., Lockport, has awarded the contract for the construction of a catalytic cracking plant to M. W. Kellogg Co., 225 Broadway, New York, N. Y. Estimated cost $15,000,000.

Pa., Marcus Hook—General Chemical Co., 40 Rector St., New York, N. Y., has awarded the contract for rehabilitation of manufacturing buildings to Rupert Construction Co., 1509 French St., Wilmington, Del. Estimated cost $120,000.

Pa., Philadelphia—Barrett Division of Allied Chemical & Dye Corp., Margaret and Bermuda Sts., will alter and build additions to five service buildings. Work will be done with own forces. Estimated cost $40,000.

R. I., Bristol—U. S. Rubber Co., 500 Wood St., has awarded the contract for the construction of a 2 story, 110x160 ft. factory to H. V. Collins, 7 Dyer St., Providence. Estimated cost $125,000.

R. I., Cranston—Atlantic Tubing & Rubber Co., Mill St., has awarded the contract for foundations, riggings and erection of 84 in. rubber mills, large presses, etc., to Henry M. Soule Co., 110 Armistice Bldg., Pawtucket.

Tenn., Chattanooga—Mohawk Rubber Co., 1235 Second St., Akron, O., has awarded the contract for the construction of a rubber tire factory to Clemmer Construction Co., 134 East Thornton St., Akron, O. Estimated cost $2,250,000. Project will be financed by Defense Plant Corp., Washington, D. C.

Tex., Dallas—Diamond Alkali Co. of Texas, South Lamar and Lenway Sts., has awarded the contract for an addition to its plant to Cedric Burgher Construction Co., 3027 Main St. Estimated cost $50,000.

Tex., McAllen—Rado Refining Co., McAllen, has awarded the contract for the construction of a new Ethyl lead gasoline plant to E. B. Darby & Co., Pharr, Tex. Estimated cost $60,000.

Tex., Orange—Kemso Chemical Products, Inc., 1203 Milby St., Houston, will construct a 45x180 ft. and 20x80 ft. building for galvanizing plant. Work will be done by owners. Estimated cost $65,000.

W. Va., Moundsville—Carboloy Co., Inc., 11177 East Eight Mile Rd., Detroit, Mich., has awarded the contract for the construction of a tungsten ore reducing plant at Natrium to Geo. A. Fuller Corp., 597 Madison Ave., New York, N. Y. Estimated cost including equipment $6,000,000.

Wis., Eau Claire—U. S. Rubber Co., 1230 Sixth Ave., New York, N. Y., has awarded the contract for rebuilding its 6 story, 135x200 ft. factory recently destroyed by fire to Geo. A. Fuller Co., 111 West Washington St., Chicago, Ill.